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# Research on Ship Collision Avoidance

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*Abstract: The intelligent research of ship collision avoidance has attracted attention in the field of water traffic safety research. After analyzing and summarizing the research results of four important intelligent collision avoidance systems at home and abroad based on expert systems, fuzzy control, neural networks, and artificial potential fields, the main aspects of intelligent collision avoidance for ships are discussed from two aspects: collision avoidance model and collision avoidance information. For the problem, the dynamic description of collision avoidance model and the division method of collision avoidance information based on weight are explained, the development trend of ship's intelligent collision avoidance system is predicted, and the research trend of three-dimensional ship and collision avoidance model online identification is analyzed.*
*Keywords: Ship collision avoidance; Intelligent shipping; Dynamic model; Three-dimensional ship*

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## 1. INTRODUCTION

In recent years, the number of shipping ships has increased sharply, the navigation density has increased, the scale of the fleet has expanded, the water level of the channel has changed, and the safe operation of ships in the navigation area has become more and more difficult. Effectively reducing the risk of collisions between ships is an important issue in the current shipping safety field. The research of ship collision avoidance system is of great significance to ship navigation safety [1]. With the development of intelligent navigation information acquisition information diversification and automation of ship control system for shipborne equipment, it has become a trend to study intelligent comprehensive collision avoidance system in combination with cybernetics, information theory and decision theory, aiming at ship's maneuvering performance and operator's thinking process. This article first introduces the ship's intelligent collision avoidance system; then describes the commonly used methods and technologies for ship's intelligent collision avoidance at home and abroad, analyzes the key problems faced by the ship's intelligent collision avoidance, and finally predicts the future development of the ship's intelligent collision avoidance system.

## 2. INTELLIGENT COLLISION AVOIDANCE SYSTEM FOR SHIPS

### 2.1 System composition

The ship's intelligent collision avoidance system first collects own ship and incoming ship information by sensors, and then transmits the data to the collision avoidance decision-making system, and the decision-making system gives maneuvering instructions, Figure 1.

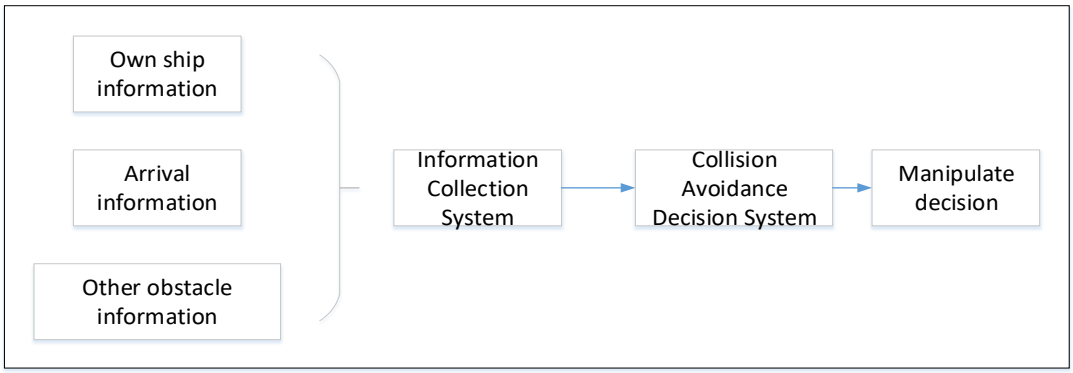


Figure 1 The structure of the ship collision avoidance system

In the traditional collision avoidance system, the criterion of collision avoidance decision is the nearest encounter distance and the time to reach the nearest encounter point. According to the size of DCPA between two ships [2], whether there is collision risk can be determined, and according to the size of TCPA, the hazard degree can be roughly determined2, In the intelligent research of ship collision avoidance system, the use of fuzzy mathematics, neural network and other intelligent optimization algorithms to comprehensively consider factors such as DCPA and TCPA.

### 2.2 General Development Overview

The research on the intelligent collision avoidance system of ships started late in China. In the early 1990s, Dalian Maritime University, Dalian Naval Surface Ship Academy and other institutions of higher learning and scientific research began to study the expert system of ship collision avoidance [3]. Among them, the ship collision avoidance expert system studied by Guangzhou Naval Ship Academy is also a kind of consulting collision avoidance expert system. The collision risk is determined comprehensively according to the DC-PA, TCPA [4], orientation and distance of the target, and the collision avoidance time is determined by the threshold method. However this system has few factors to consider in the evaluation of collision risk, and the division of meeting situation is still rough. Later, with the deepening of the research on intelligent optimization algorithm in foreign countries, domestic scholars have also proposed a ship collision avoidance system based on a variety of intelligent algorithms. However, the research on intelligent collision avoidance in China is relatively scattered, and the research results are far from being practical.

## 3. THEORY AND METHOD OF SHIP INTELLIGENT COLLISION AVOIDANCE

### 3.1 Intelligent collision avoidance system based on expert system

The composition of the ship collision avoidance expert system is shown in Figure 2. The intelligent ship collision avoidance system is the result of the application of the expert system in the direction of ship collision avoidance. It is characterized by the separation of the knowledge base and the inference engine. The intelligent algorithm in the field of ship collision avoidance uses this result first. Theoretically, the knowledge base of the collision avoidance expert system has comprehensive coverage, which can basically solve the problem of ship collision avoidance. The intelligent ship collision avoidance expert system is a research hotspot in the future ship intelligent collision avoidance system. Currently, applications in the field of ship collision avoidance are based on shipboard automatic identification systems, automatic radar plotters and intelligent collision avoidance expert systems combined with other technologies.

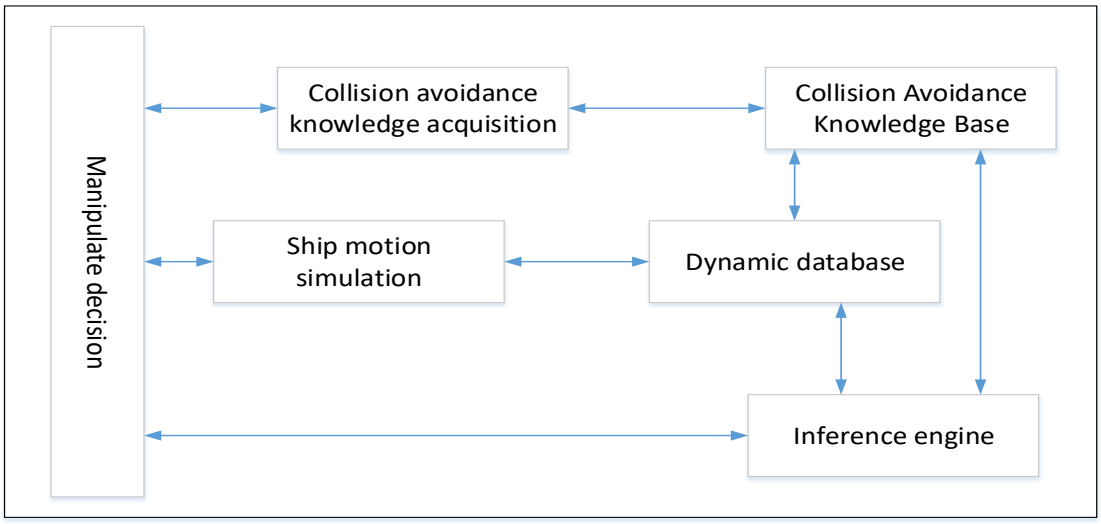


Figure 2 The composition diagram of the ship collision avoidance expert system

3.1.1 AIS based collision avoidance expert system

In recent years, Dalian Maritime University and Wuhan University of Technology have conducted more in-depth research on the collision avoidance expert system based on AIS. The research of Dalian Maritime University started earlier, systematically presents the collision avoidance model of AIS and expert system fusion, as shown in Figure 3.

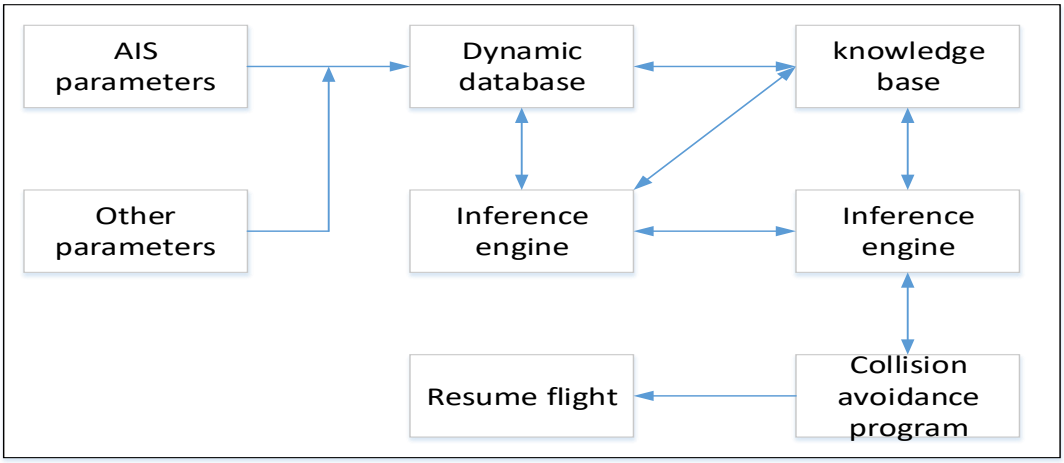


Figure 3 AIS based collision avoidance expert system for ships

The system integrates AIS data into the collision avoidance knowledge base of the expert system, and can use AIS to update the database in real time, and use the inference engine of the expert system to analyze collisions with the rules of ship navigation and collision avoidance experience.

Since then, some scholars have discussed and studied the collision avoidance rules under different collision avoidance conditions, such as single vessel avoidance and multi-vessel avoidance. Qu qingquan [5] adopting multi-rules to support the same fact reasoning of collision avoidance expert system, a multi-vessel automatic collision avoidance system based on AIS is proposed. Wuhan University of Technology In the study, taking various situations into consideration, the avoidance rules are subdivided into: direct avoidance of a single ship, avoidance of key ships first when multiple ships are involved, and updating the status after success [6]; lf there is no obligation to avoid, and the target ship does not avoid, then re-enter the collision avoidance decision. However, AIS data has the shortcomings of poor real-time performance and easy data loss, and it needs to be repaired after the information is obtained.

3.1.2 Collision avoidance expert system based on radar ARPA and AIS fusion

AIS and radar data are complementary, and radar has the advantage of active detection, which can detect both stationary and moving targets at the same time. However, radar targets are restricted by blind areas and are prone to missing detection. At present, scholars in Harbin Engineering University have made a systematic and systematic research on this subject10JA model of AIS and radar data fusion is presented [7]. The principle of this model is shown in Figure 4. Time extrapolation method is adopted to calibrate the sampling time. Fuzzy mathematics method is adopted to associate the track.

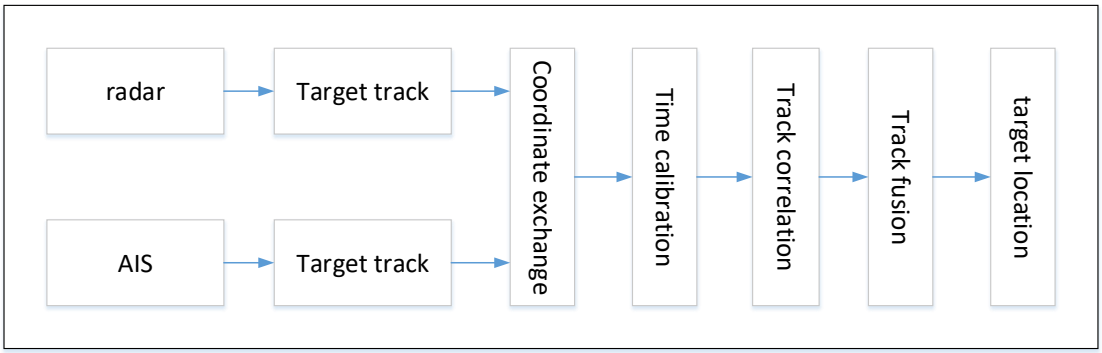


Figure 4 Schematic diagram of AIS and radar data fusion model

3.1.3 Other expert systems

The research on the calculation method of ship collision risk in the expert system takes weight division and threshold judgment as the main direction. A method of using weights to divide the target risk is proposed, and when the weight of the current dangerous target remains unchanged, the collision avoidance decision is updated by adding the next collision avoidance target. This rule can deal with emergencies after avoidance. When RDRR reaches the threshold value, the start time, amplitude and end time of avoidance are calculated [8], The improvement of the collision avoidance model of the expert system is mainly reflected in the dynamic optimization of the knowledge base and the integration of other algorithms.

Among them, the classic method proposed by H.J.Lee and K.P.Hee [9]is to use A * search algorithm to integrate expert system to plan the optimal collision avoidance path. This method makes use of the fast convergence of A * intelligent search algorithm to improve the efficiency and adaptability of collision avoidance reasoning in expert system. At present, the intelligent research of collision avoidance system based on expert system is embodied in the optimization of collision avoidance knowledge base and reasoning engine. The advantage is that knowledge base and reasoning are independent and interact with each other, which is convenient for modularization. However, due to technical limitations, this system is relatively simple and cannot handle real-time non-deterministic problems. It needs further optimization.

**3.2 Intelligent collision avoidance system based on neural network**

The use of neural network can realize the learning and memory of uncertain parameters in the collision avoidance system, making the intelligent collision avoidance system based on neural network become an important development direction of intelligent collision avoidance system. The collision avoidance system based on the neural network USES the samples after the neural network memory training to form experiences. The controller USES these experiences in the associative

memory way, and makes decisions by integrating them with other decision-making systems. The operating block diagram of the system is shown in Figure 5.

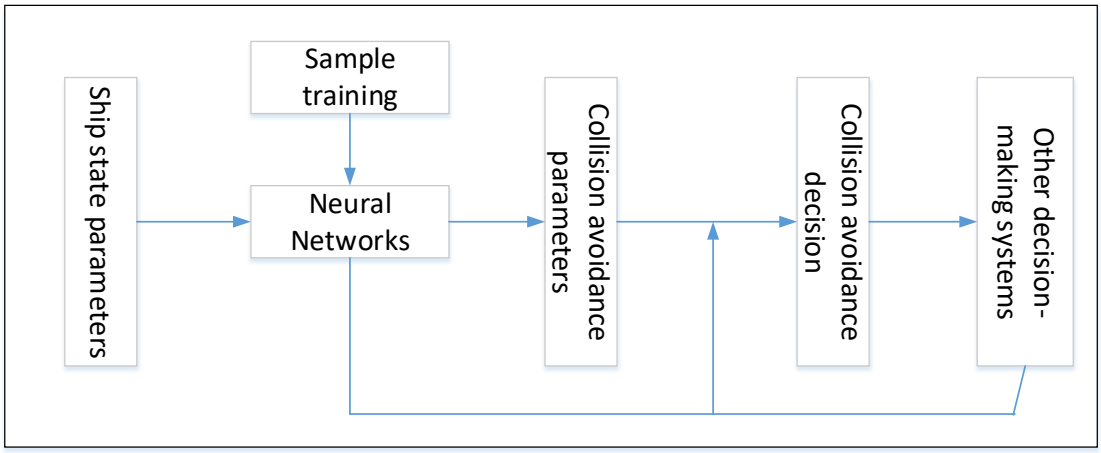


Figure 5 Neural network collision avoidance system

At present, neural network is integrated with expert system, fuzzy control and other collision avoidance methods to realize intelligent collision avoidance.

## 4. THE RESEARCH PROSPECT OF SHIP INTELLIGENT COLLISION AVOIDANCE

### 4.1 Information acquisition technology

The development trend of ship collision avoidance information acquisition technology in the future is as follows.

1) Diversified information acquisition technologies. Beidou positioning technology is the global positioning technology of China's Beidou satellite navigation system[10]. The positioning system has oblique orbit satellites, and has higher positioning accuracy in complex terrain. It closely combines navigation and communication. It has the function of short message messages. The terminal equipment can not only receive Beidou positioning signals, but also send terminal information to satellites or to the control center is the future research trend of ship navigation information acquisition technology.

2) Three-dimensional collision avoidance field. Based on the width and height information of the ship passing area between the bridge piers, the watercraft field is established, and the underwater ship field is established by the water depth information of the port or the inshore waterway. Combining the water surface ship field around the ship can form a three-dimensional collision avoidance in a complex navigable environment. Ship field. In this field, collision risk information is also divided into three aspects: water surface collision risk, grounding and ship bottom collision risk, and water hull collision risk. In addition, the integration of ship-shore information also provides more channels for information sources of ship collision avoidance.

### 4.2 Collision avoidance model

The research of intelligent control theory and algorithm makes more advanced decision-making algorithms be introduced into ship collision avoidance decision-making, and optimizes the real-time performance, rapid convergence and solution pros and cons of existing applied algorithms. Avoidance model in the dynamic online environment and modify the parameters of the model with the constantly feedback information data. At the same time, the decision-making algorithm must have strong

convergence ability and better accuracy, so that the model can quickly and timely represent the current collision risk of ships. The modeling method based on online identification, as shown in Figure 6, will become the trend of future decision algorithm model research. At present, support vector machine (SVM), as a hotspot in pattern recognition, has become a new field in intelligent collision avoidance of ships in recent years. This method is based on statistical learning theory, and compared with neural network, it has the advantage of avoiding dimensional disaster[11]. The learning efficiency of this algorithm is only related to the number of samples, and has nothing to do with the data dimension that needs to be solved. Therefore, it can provide a better real-time modeling method for the decision-making algorithm of multi-input (heterogeneous collision avoidance information) system of ship collision avoidance decision, and is an effective means to study the identification and optimization of collision avoidance model[12].

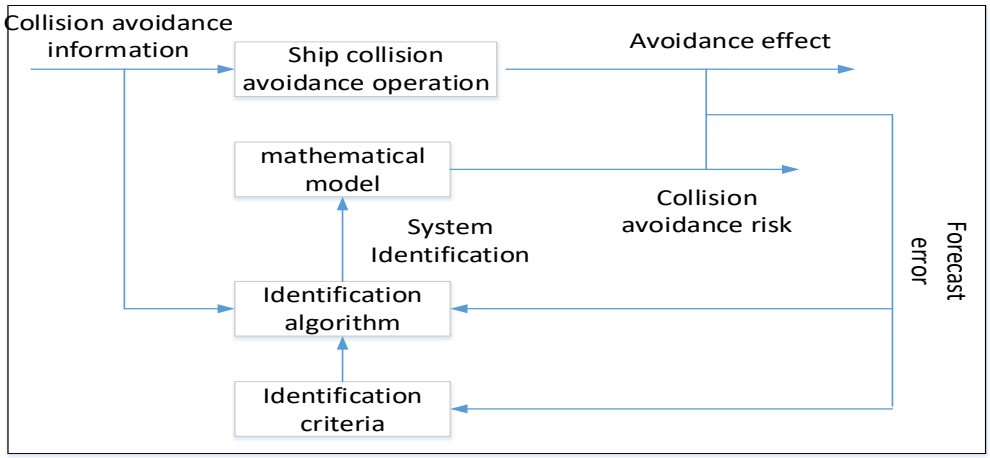


Figure 6 Online identification of collision avoidance model

## 5. CONCLUSION

In this paper, the structure and development of intelligent collision avoidance system for ships are summarized, and the composition and research progress of intelligent collision avoidance system based on expert system, fuzzy control, neural network, intelligent optimization algorithm and artificial potential field are introduced emphatically. On this basis, the main problems existing in the field of intelligent ship collision avoidance are analyzed from two aspects of collision avoidance model and collision avoidance information, and the solutions are given. The development trend of information acquisition technology, collision avoidance model and collision avoidance application of ship intelligent collision avoidance system are prospected accordingly. With the development of shipping industry, the safety of ships has attracted much attention. In the near future, it will be possible to widely use advanced intelligent collision avoidance systems in various fields.

## REFERENCES

[1] Sheng Jinlu, ZHAO Hugang, Yang Fuhua, et al.Research status and Trend analysis ofcollision avoidance decision on inland river ships [J]. World Shipping,2015 (3) : 37-40.

[2] Zhang Xiaotu, LIU Zuyuan, ZHANG Lewen. Overview of intelligent research or ship collision avoidance systems [J]. Ship Engineering, 2000 (1) : 45-48,4.

[3] Li hao. Application research of AIS based ship collision Avoidance Expert System [D]. Dalian: Dalian Maritime University, 2004

[4] QuQingQuan. AIS based Multi-vessel automatic collision avoidance expert system [D]. Dalian: Dalian

Maritime University, 2005.
[5] Li-li peng. Expert System and Implementation of AIS Based Intelligent Collision Avoidance system for Inland River Ships [D]. Wuhan: Wuhan University of Technology, 2010
[6] Wu Gongshuang. Design and Implementation of ship collision avoidance terminal based on ATS/Radar fusion information D]. Harbin: Harbin Engineering University, 2013.
[7] Yang Xing, ZHU Dagi, SANG Qinghing. Current situation and Prospect of expert system research [J]. Computer Application Research, 2007 (5) : 4-9
[8] Xue-juan Chen. BP neural network is adopted to optimize the collision
[9] Shi Pingan, Chen Wenwei, Wang Jingquan, etc. Research on composite collision avoidance expert system based on neural network [J]. Navigation Technology, 2001 (6): 2-5.
[10] Xu Yanmin. Collision avoidance fuzzy expert system [J]. Journal of Wuhan University of Technology (Transportation Science and Engineering Edition), 2002(3): 407-410
[11] Liu Qing. Research on Fuzzy Neural Network Control System of Ship Maneuvering Movement [D]. Wuhan: Wuhan University of Technology, 2002.
[12] Zheng Zhongyi, Wu Zhaolin. Calculating the hazard of ship collision with BP neural network [J]. World Shipping, 2000(2): 4-6.