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A review of research on ships domain and its influencing factors

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Abstract

With the continuous increase of ship scale and transportation intensity, the risk of ship collision is also increasing gradually. As an important index for the study of water traffic safety, the field of ship is also the focus of the study of water traffic safety. In order to study of ship domain and its influencing factors analysis, first of all, through summarizing domestic and foreign experts on corresponding views and research in the field of ship model, then carries on the comparison to the results of this study and its main features analysis, finally, considering the influence factors of ship domain, a clear direction for the future research fields of ship model and further improve the ship domain model to lay the solid foundation.

Keywords

Ship domain, Model, Influence factor.

1. Introduction

The field of ships is the waters around ships that are not allowed to enter during navigation. It not only plays an important role in the evaluation criteria of ship navigation risk, but also plays a key role in maritime safety navigation. It is widely used in maritime traffic, especially in risk assessment of collision avoidance[1]. Vessel traffic accident cause serious environmental damage and loss of life and property, according to the statistics released by the Ministry of Transport results all of 2019 were a national level and the following Chinese transport ship water traffic accident of 128, 140 people die missing, 42 ship wreck, the direct economic loss of 170 million yuan, the incidence of ship collision accident and comfortably in the forefront of the Marine water traffic accident[2, 3], a collision of research also has been an important content of the water traffic safety research[4-6].

For a long time, the field of shipping has been the hot spot of Chinese and foreign scholars. Since Fujii and Tanaka[7]first put forward the concept of ship field in the 1960s, many experts and scholars have done a lot of researches according to the shape, size and influencing factors of ship field[8-12]. Sailing ships as evaluation and the key indicators of avoiding collision[13], similar to CPA, in recent years intelligent ship research undoubtedly plays an important role, ship field not only for ship collision risk assessment and ship collision avoidance has a broad application [14-17], and in the vessel traffic flow modeling and capacity estimation are also has the vital role [18-20], thus to ship around in the field of security research has important significance. Based on the main research results in the field of ships at home and abroad, this paper summarizes the classic conceptual models in the field of ships, and finally analyzes the factors affecting the field of ships, so as to make contributions to the future development and improvement of models in the field of ships and intelligent collision avoidance of ships.

2. Overview of ship domain

2.1. Ship domain concept

Ship domain is a conceptual domain. In order to ensure the safety of Ship navigation and keep away from other ships and obstacles, the domain around the Ship that avoids other ships[21,22] is one of the criteria for the risk assessment of Ship navigation, as well as one of the parameters used in maritime collision avoidance planning and traffic engineering[23]. The concept of ship field was first proposed in 1963 by Dr. Fujii, a famous scholar who pioneered maritime traffic engineering in Japan, when studying the traffic capacity of a narrow waterway, combined with the research results of road traffic[24]. He defined the ship field as the area around the previous ship that most subsequent ship pilots avoid. Its boundary is selected as the boundary of the field where the density around the obstacle reaches the maximum value point when the traffic flow with uniform density passes through an obstacle in a channel[7,25]. Up to now, scholars at home and abroad have not formed a unified standard for the concept of the field of ships. According to the purpose of developing the field model, there are various definitions of the concept of "the field of ships"[26], but the meaning is basically the same. Traditional research in the field of ships defines the field of ships as the area where navigators want to keep a distance from other ships or objects from the psychological perspective of captains[7,8,27]. At present, the definitions generally accepted by experts and scholars are proposed by Fujii and Tanaka[7], Goodwin[27] and Coldwell[28]. The early definition of ship field was proposed in the 1970s by Fujii and Tanaka[7], "in the area around a ship during navigation, most pilots following a ship should avoid entering the area". Fujii and Tanaka[7] defined the ship field based on the Angle of other ships. Later, British scholar Goodwin[27] further perfect existence in the field of the ship, set up a model of open waters, further ship domain is defined as a ship around waters, the driver wants to keep the ship around the vessel to avoid other ship or obstruction into needed to maintain safe navigation waters, including Goodwin[27] is based on the viewpoint of the vessel to the definition of the Marine areas. In the mid-1980s, Coldwell[28] improved the restricted waters model of Fuji and Tanaka[7] and Goodwin[27]. Taking into account the international Rules for preventing collisions at sea (COLREG), a ship's domain was defined as "the effective waters around a ship that a typical pilot of a ship actually maintains, taking into account the presence of other ships". Jingsong et al[29] argued that most of the definitions in the field of ships emphasize the waters around ships in order to ensure navigation safety and eliminate the risk of collision. Professor Jia Chuanying of Dalian Maritime University said that the field of ships is the waters needed by ships to ensure navigation safety and avoid collision. Guo Zhixin[31], a scholar from Wuhan University of Technology, believes that the boundary of the shipping field should be somewhere between the two critical quantities when the situation is urgent and the danger is imminent. In the principle of ship collision avoidance, there is also a simple definition of the boundary of ship domain: technically speaking, the boundary of ship domain is essentially the track that safely passes through the outer end point of the radius of DCPA.

To sum up, the ship domain refers to the water area reserved by the ship's pilot in order to ensure the safe passage of the ship without collision with other ships when other ships approach. Similar to the concept of imminent danger, where an imminent danger is a situation where a collision cannot be avoided by the actions of a single direct vessel when two ships approach. If the other vessel or object enters the area, the likelihood of collision will be greatly increased.

3. Ship domain model

Scholars since the early 1960s Japan Fujii, puts forward the concept of ship domain since Dr Closing international scholars study of ships, shipping in the field of research development is rapid, so far has put forward the various forms of ship domain model, in recent years, due to the provisions of the international maritime organization (IMO) AIS installation requirements, AIS data[32,33] capture more and more used in Marine field, the field model is representative in the field of ship model with Mr Fujii, Goodwin model and domain model octagon ships, etc.

3.1. Fujii model

In 1963, When studying the traffic capacity of a waterway, Japanese scholar Mihei Fujii first put forward the concept of ship field, and established the ship field model and corresponding size of Japan's coastal waters by means of traffic survey and statistical probability[34]. The ship field model is still used in the field of Marine traffic engineering. Dr Fujii has studied shipping, using an obstacle in a passage through which traffic flows in uniform densities. The elliptical ship field centered on the avoided ship is proposed. He believes that the model and the corresponding scale of the ship domain are related to the factors such as ship speed, ship length, visibility, density and tidal current. According to Dr Fujii, Japan coastal waterway long-term observation, finally calculate the ship scale in the field of concrete numerical: long axis for seven times, short axis is 3 times as the captain, captain under the condition of normal navigation overtaken ship half shaft length field scale of 8 L and 3.2 L, when sailing in the narrow strait and need to slow down inside the port, ship half shaft length field scale reduced to 6 times L and 1.6 L short axis[35].

3.2. Goodwin model

In 1976, Goodwin, a British female scholar, proposed a ship field model in open waters after conducting maritime traffic observation in the south sea of the North Sea and conducting collision avoidance experiments using crew training opportunities on the radar simulator of The City Institute of Technology in London[36-38]. In fully aware of the "international regulations for preventing collisions at sea" impact of ship collision avoidance behaviors (rules out of different position on the different collision avoidance action principles), Goodwin thought in the field of ship geometry for asymmetric model, and will ship the lamp range will ship domain is divided into three sectors, including the first part is the radius of 0.85 n mile ahead to ship the right beam after 22.5 ° of the sector, the second part is the radius of 0.45 n mile is rear to ship around beam after 22.5 ° sectors, The third part is the sector of 22.5° from the front of the ship with a radius of 0.7n mile to the left beam.

Goodwin believed that the ship field is the necessary scope for any ship to ensure navigation safety, and its size is closely related to the ship's master, maneuvering performance, traffic density, sea area type and other factors[27].

The ship field models established and improved by Fujii and Goodwin have certain similarities, but they also have certain differences due to their different research ideas and methods. Fujii ship domain model is mainly aiming at the condition of the ship overtaking a waterways, and Goodwin mainly aiming at ship in open waters in any encounter conditions of model, in addition, Fujii mainly using observation data of small vessels in the coastal waters and Goodwin use tonnage is mainly large ships, the ship domain model proposed by Goodwin Fujii model have a very good supplementary effect.

3.3. Van-der Tak medel

In 1977, A Dutch scholar, Van-Derek Tak, combined the advantages of Fujii and Goodwin in the field of ships and proposed the Van-der Tak model[39]on this basis. Ships are still oval shape, but will ship center position backward and deflection of the delta to bow to left, center, port and starboard stern ship's part of the area of three areas roughly with Goodwin is proportional to the area of the three sectors of ship domain model, and the elliptic revised ship domain, elliptic half shaft length 1.5 n mile and 1 n mile, when determining the new ship field according to the ship's maneuverability, pilot qualifications, psychological factors, reaction time and the environment determine the kinds of different tonnage and other vessels in the field of multiplication factor for various areas of the ship size, etc.

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3.4. P.A.Davis model

In 1980, the British scholar P, A, Davis[40,41]in the use of computer simulation to study the ship's encounter with collision avoidance, found Goodwin boundary discontinuity of ship domain model, is not convenient to application and so on Goodwin ship domain model to carry on the smoothing processing, come up with A circular domain model, Davis with A ranging and Goodwin ship domain model in three sectors area is equal to the sum of the circle to replace the original domain model, in order to reserve the advantages of Goodwin model, Position the boat at the lower left of the circular field and allow the newly acquired three sectors to retain the scale of the smooth boundary. This model, which focuses on practical application, is more suitable for the study of computer simulation in maritime traffic engineering.

3.5. Other ship domain models

In 1981, abdel-Galil, when studying the ship overtaking collision in the south North Sea and the Strait of Dover, put forward that the standard division between ships also belongs to the field of ships, and the size of ships is related to factors such as tonnage of ships[42], by integrating ship maneuvering performance, ship size and hydrodynamics principle.

In 1983, the British scholar Goldwell 19 n mile a river in the sea lanes of more than 200 ships were observed, and the observed data of ship classification statistics, finally draw overtaking and the situation of ship domain model, where a ship is involved in overtaking and cases, the ship domain model is ellipse, where a ship is involved in among them, the ship domain model for half shaft length for 6.1 n mile and 5 n mile and a half elliptic, slightly shift to the left and center position of ship; In the case of chasing, the ship field model is an ellipse with long and long semi-axes of 6.0n mile and 1.75n mile, and the center ship is located at the center of the circle[28]. Goodwell also confirmed that Fujii model is also applicable in the case of catch-up[43,44].

In 1989, Dalian Maritime University professor chuan-ying jia in crowded waters ship field is put forward in the field of ship size is not invariable, in different ship maneuvering performance, the driver, the navigation environment and under the influence of speed, can change ship domain, thus, professor chuan-ying jia variable size of ship domain model[30]. The ship domain model is an ellipse proportional to length and short axle and length and width.

In 1993, experts and scholars such as Zhao Jinsong, Wu Zhaolin and Wang Fengchen based on M. K. James' DCPA decision simulation model[45], conducted a questionnaire survey among more than 50 captains and pilots as well as experts and scholars, and applied fuzzy mathematics theory to obtain a fuzzy ship field model[46-48].

In 2000, Lisowski[49]et al. proposed a ship domain model based on neural network, and attempted to apply the neural network to determine the scope of ship domain.

In 2000, Dalian Maritime University professor xiu-ying bi[50]on the basis of the risk of a collision, the analysis of the dynamic boundary and the domain of research status quo, and established the boundary by combining with the AIS data collision risk threshold while under the influence of change of ship dynamic collision avoidance behavior domain model, when the risk of a collision meet the threshold, ship certain collision avoidance action to avoid entering the areas within the scope of the ship.

In 2001, Smierzchalski R et al[10,51]proposed a complex ship field model with a hexagonal shape. The dimensions of each side were determined by ship data, such as ship speed and cycle parameters.

In 2002, Dalian Maritime University professor zheng [52]with the method of open questionnaire, for ships collision avoidance behavior of drivers were investigated, then the method based on fuzzy mathematics and neural network, the nature of the analysis of collision risk, and puts forward the concept of space collision risk and time collision risk, and finally it is concluded that under the condition of different collision risk of ship safety domain.

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In 2003, kijima.k and furukawa.y[53,54]proposed the ship domain based on the blocking area and the observation area through statistical analysis of data, wherein the observation area could be used as the guard area to guarantee the blocking area, which promoted the development of the ship domain model.

In 2006, Dalian Maritime University professor sun information survey[55]by analysis of ship collision avoidance behavior of navigation, and the process of collision accident and automatic collision avoidance system is studied, and the income of ship domain compared with many other types of ships, will eventually result applied in ship collision avoidance decision-making system.

2008, Pietrzykowski by the relative position between the two ship, distance and heading out factors as input variables, the risk of ship course as the output variable, and in the form of artificial neural network[1]to study the empirical data, the relationship of the input variable and output variable, get fuzzy boundaries, in the field of ship in the end put forward the dynamic fuzzy domain model of the ship.

In 2008, guo Guoping and Chen Houzhong[56], when studying the ship field model in the bridge area, established the rectangular ship field model by studying the layout characteristics of the holes in parallel Bridges across inland rivers and combining the hydrodynamics and ship handling performance. This model can be used to further calculate the ship's passing capacity in the water area.

2009, Pietrzykowski simulated experiment using two ships, a ship as the center, another ship for the target ship's personnel according to their own knowledge and experience to determine the sailing ship, the safe distance between after considering the condition of different ship encounter, comprehensive methods such as fuzzy logic and neural network of the octagon ship captain under the condition of different model[57, 58], This model integrates the ship tonnage, ship speed, ship maneuvering performance, navigation density and positioning accuracy, as well as the speed of other nearby ships and their relative speed with that of the ship, the navigation knowledge and experience of ship pilots and the degree of receiving navigation education and training, etc[58-60].

In 2010, Wang Ning[9]build ship domain model under the condition of the four elements, after comprehensive consideration of man, machine, environment factors and puts forward the dynamic field of four yuan ship model[9,61,62], makes the intelligent level of ship domain model and practical increased significantly, and based on fuzzy mathematics theory to establish more practical quaternion field of the ship.

In 2013, Hansen M G, Jemsen T K et al[63]used field observation and statistical methods to study the field of ships. By extracting the ship AIS data in the southern waters of Denmark for four years, they carried out statistical superposition of a large number of ship AIS data and drew the ship field model in open waters.

In 2015, Zhang L et al[64]used AIS data to study the distribution of safe distance between ships. Weng et al[65]proposed a method to evaluate the frequency of ship collision risk using the ship field. That same year, Shanghai maritime university to xiang Dr.[66]based on AIS data, such as using the grid frequency method, this paper proposes a restricted waters calculation method in the field of the ship, and selected the hainan channel of AIS data on the test, finally draw a limited waters the length ratio of length and ship is not a fixed value, but increased with the increase of ship length decreasing.

In 2015, Shaoman Liu, Kai Zheng, and Zhaolin Wu et al[67]used a new calculus to assess ship passage capacity in inland waterways.Taking ship dynamics, driver reliability and environment into consideration, they proposed a new dynamic quadrangle ship domain model, and verified the effectiveness and practicability of the model in The Waters of Yin Gongzhou.

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In 2016, zhou Dan et al[68,69]used neural network model and rough set theory to model and analyze the relationship between the ship field and its influencing factors, and the results obtained had a relatively high degree of fitting.

In 2016, Dalian Maritime University Li Guoshuai, zhang wenjun [70]on the basis of ensure the ship navigation safety in order to saving the cost of oilfield exploitation Fujii ship domain model correction was proposed, which put forward a new calculation model, the model fully consider the influence of factors such as wind and rig safety concept, application of the model can ensure the safety of the drilling rig distance between customary route distance.

In 2016, Wang and Chin[71]proposed a free-form asymmetric polygon region. First, they assumed that the size of the ship domain was a function of the ship length and speed. Then, they used genetic algorithm and based on the AIS data of Singapore Port and Singapore Strait to conduct calibration of the model in this domain.

In 2016, wuhan university of technology Fan Xianhua, Zhang Qingnian[72]to study the flow factor for the impact of ship navigation, water flow is studied under the condition of inland river ships domain model, on the basis of the original put forward a new kind of inland river ships domain model, and the direction of flow to analysis the impact of inland river ships.

In 2019, Horteborn et al[73]reviewed and proposed a method using AIS data in Swedish waters. It is also obtained that the ship field is an ellipse with a half-axis radius of 0.9 and 0.45n mile, and that the total length of the ship is the determining factor of the static field of the ship in open waters and the dynamic field of the ship in restricted waters.

In 2019, Zhang et al[74,75]proposed the concept of probabilistic ship domain for restricted waters, and focused on the development of a method to determine probabilistic ship domain driven by statistics of a large number of AIS data. They point to the use of the probabilistic ship field to assess the risk of ship collisions. The ship probability domain determined by AIS data is different from the traditional ship domain in which AIS data was not available in the early stage. In the same year, Zaccone et al[76]proposed that the probabilistic vessel field does not indicate the boundary where the target vessel must take action once it approaches the target vessel and encroachs its domain. The shipping field is used to judge the level of risk when it occurs, not when it happens. In order to use the probabilistic ship domain for collision risk assessment it is necessary to know when the ship domain invasion occurs. The probabilistic ship domain contains navigation behavior information, which reflects the judgment of the pilot when considering the collision risk. To ensure safe navigation, ships must keep a safe distance from other ships.

Above all, about the research status in the field of ship can be summarized as: begins by Fujii model and Goodwin model, many scholars at home and abroad constantly enrich the domain model, field theory and improve the ship makes the further research in the field of ship and sail to specific areas and specific status more and more researches on the ship, field by oval shape, fan gradually developed into a polygon, dynamic model and so on.

4. Influential factors in the shipping field

In the aquatic transportation system, the field of ships is related to many factors such as ship size, ship maneuverability, hydrological conditions, meteorological conditions, sea area type, ship speed, traffic intensity, navigator knowledge and so on[77-80].The influencing factors can be summarized as the ship's pilot, the ship's condition and the external environment, etc. However, the ship is subject to the international Rules for Preventing Collisions at Sea during navigation. Therefore, the influencing factors in the shipping field can be roughly composed of man-machine-ring-pipe factors, namely, the changes of the ship's pilot, the ship's condition, the external environment and the International Rules for Preventing Collisions at Sea, etc., will all have different degrees of influence on the shipping field.

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4.1. Ship pilot factor

Ship the quality of drivers, driving experience, ability to respond to will have an effect on Marine areas, such as the driver driver's quality mainly refers to the ship sailing by the education of knowledge and master degree and the ship maneuvering technology proficiency, nowadays, AIS is widely used, will record the ship at the same time the driver for the actual manipulation of the environment on the[18,81], there is no doubt that has a higher request to ship the driver's quality, a good sailing ship pilots should have rich knowledge and skilled technology in ship maneuvering, To a more reasonable certainty of the accused of ship navigation safety distance and the timing of the collision avoidance action taken, at the same time, the driver driving experience may also affect the ship in the psychological state of collision avoidance action and action time and amplitude of action, in the end, the driver's ability to respond will also lead to the effectiveness of the ship domain, compared with quick driver, ships may be relatively small. These factors always affect the safe distance between a ship's pilot and other ships during navigation and determine the pilot's judgment of the ship's field.

4.2. Ship condition factor

1) Ship size

The size of the ship has a very close relationship with the size of the ship field. Different ship scales represent different length, width and tonnage of the ship, and the area occupied by navigation and the maneuverability of the ship will also change accordingly. The larger the ship size is, the greater the influence of ship inertia, rudder efficiency, and wind-affected area on ship maneuvers will be. Compared with smaller ships, the larger the safe distance maintained by ship pilots will be, and the larger the field of ships they need will be.

2) Ship type

Different types of ships, their USES and the cargo they carry, have different potential hazards, as well as the speed and handling performance of the ship. Ships carrying dangerous goods, such as oil tankers and chemical tankers, require a greater safe distance than ships carrying ordinary goods, so different types of ships require different areas of ships.

3) Ship maneuverability

Control performance is different, will directly determine the ship the timing of the driver's collision avoidance action, but also determines the driver to keep the ship safety distance, finally will affect the ship pilot needs to determine their own ship the size of the area, in general, the worse performance of ship maneuvering performance compared with other control good ship should maintain a greater safety distance, that is to say, poor maneuverability of the ship of the ship's field tend to be greater than the ship maneuverability good field of a ship.

4.3. External environmental factor

Compared with ship pilots and ship conditions, external environmental factors are also an important factor affecting the field of ships. The external environment can be divided into natural environment and navigable environment. And the natural environment can be divided into hydrological conditions, meteorological conditions, navigation conditions; Navigable environment is divided into vessel traffic management system, alignment regulation, navigation mark, etc. The following two aspects will be analyzed from the natural environment and navigable environment.

4.3.1. The influence of natural environmental elements

1) Hydrological conditions

When a ship is sailing in different waters, due to the different hydrological conditions, the ship's speed, course and stroke, etc. will be affected, thus affecting the safe distance of the ship and finally affecting the field of the ship. When the ship is sailing downwind, downwind and downstream, the increase of the ship's speed leads to the increase of the ship's parking and reversing stroke, and the field of the ship will be further increased. Conversely, the field of ships will decrease; When the ship is subjected to the action of cross wind and cross flow, the ship will move sideways and sway from side to side. At this time, the ship field will be further enlarged. Therefore, under different hydrological conditions, the shipping field will be different.

2) Meteorological conditions

The ship will also be affected by wind, rain, snow, fog and other factors in different waters during navigation. The wind direction will cause the ship to drift, which will directly affect the safety distance of the ship. However, factors such as rain, snow, fog and so on will affect the visibility, which will lead to the deterioration of ship pilots' observation and judgment ability, which will indirectly affect the safety distance of ships and ultimately affect the ship field.

3) Channel conditions

The channel conditions mainly include the class of the channel and the length of the channel. Channel, the higher the grade, tonnage allowed through, the greater the sailing ship speed, the higher the[82], and the demand of the ship safety distance will also vary, the longer the length of the channel, vessel to take up the greater the cycle of waterway, per unit time through the channel, the less the number of ships channel capacity is small, then affects the size of the ship domain.

4.3.2. Influence of navigable environment elements

1) Vessel traffic management system

The implementation of the vessel traffic management system makes the passage of inland river vessels safer and reduces traffic jam caused by accidents, thus indirectly affecting the field of vessels[83].

2) Provisions of alignment system

Ship alignment system is a system in which shore-based departments specify the routes, routes or navigable lanes that ships should follow or adopt when sailing in certain areas of the sea in the form of regulations or recommendations, so as to improve the navigation safety of ships. The ship routing system can be divided into lane separation and navigation system, ring road, coastal navigation belt, two-way route, recommended route, recommended route, deep water route, warning zone, avoidance zone, anchorage ban zone, etc., which can be used separately or in combination according to actual needs. In the waters specified by ship alignment system, the encounter type of ships will change. For example, the ship domain model established by Goldwell for the encountered situation is a half ellipse of the center ship offset to the left, while the ship domain model for the catch-up situation is an ellipse of the center ship located in the center of the field. This in turn has led to changes in the shipping field.

3) Navigational AIDS

Perfect navigation aid marks can facilitate navigation aid for inland river ships, reduce ship grounding and collision accidents during navigation, and indirectly affect the size of the field of ships.

4) Vessel flow velocity distribution

In general, the speed of the vessel traffic flow is often by vessel traffic flow in the slower shipping decision, ships in the process of sailing, because of the influence of water flow upward speed will be significantly less than the downward speed of the ship's, this also caused the up will be less than the speed of the ship stream down ship flow velocity, vessel area because of the different speed.

4.4. Factors of international Rules for Preventing Collisions at sea

As ships are restricted by the International Rules for Preventing Collisions at Sea during navigation, there are different regulations on ship speed, different types of encounters and

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avoidance of ships, which lead to differences in the field of ships. For example, in the International Rules for Preventing Collisions at Sea, the provisions of Article 6 for safe speed, Article 13 for overtaking, Article 14 for opposite situations, Article 15 for cross-meeting situations and Article 19 for poor visibility, etc., these provisions restrict the movement of ships and thus lead to differences in the areas of ships.

To sum up, the field of shipping is not only affected by many factors, but also affected to the same degree under different conditions, so it is difficult to analyze each factor. In terms of the four factors mentioned above, the human factor has too many variables and is generally not discussed, while the other three factors can be further analyzed to further deepen the research in the field of ships.

5. Conclusion

Based on ship model and its influence factors, this paper starts with the definition of domestic and foreign experts and scholars to the ship domain, focusing on the analysis of several classic foreign ship domain model, with the acceleration development of ship domain model research at home and abroad, the ship domain model is more and more perfect, the oval, gradually developed into a polygon sector, a dynamic model, etc., applicable waters is becoming more and more wide, the influence factors of research more and more comprehensive, when considering the influence factors of Marine areas, due to the uncontrolled human factor, can temporarily don't consider, emphatically analyzed the other three kinds of influencing factors. In order to further study the field of shipping and its influencing factors, it is necessary to refer to the research results of more domestic and foreign experts and scholars in relevant fields and consider more factors that may affect the field of shipping.

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