

Original article

**The combination of analytical and statistical method
to define polygonal ship domain and reflect human experiences
in estimating dangerous area***

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Abstract

The paper suggests a new method of collision avoidance stemming from the concept of the polygonal target ship domain. Since the last century, we have witnessed the current typical ship domains classified and described. In this proposition, firstly, the domain is a geometrical manner which is used in both analytical and statistical method, resulting in the signification of practical application and simulation. Secondly, such domain will be applied to target ship under the combination of two separated parts: “Blocking area” and “Action area” in order to define the area where the ship must keep outside and how the actions to avoid collision can be generated. Thirdly, the concept has suggested the number of mathematical models for different approaching encounters, including head-on, overtaking and crossing situation. Finally, the parameters of turning circle of the ship can be proposed in determining the size of the domain. Statistical evidences indicate that this method reflects a crew’s real habit and psychological in maneuvering. As the result, simple domain is shaped like imagination of sailors, but more accurate in calculating boundary. It promises an effective solution for automatic collision avoidance method. The next researches of this paper have achieved positive results in finding shortest route for avoiding collision. Moreover, while using statistical methods, classical researches face a serious problem in a wide application with different areas, this concept can make up a beneficial solution for the popular application. The numerous ship domains which are in previous researches will be carried out to compare and point out the simplification and effectiveness of the new method in practice.

Keywords: Ship domain, Blocking area, Action area, turning circle, advance distance of turning circle

I. Introduction

Over the past decades, by analyzing the vital statistics of accidents at sea, it was irrefutable that the main reason of disaster derives from human factors. Over 80% of collision started from human's neglect and irresponsibility. Views on this issue vary from part to part. It is difficult to assume that an officer can keep watching every single second during all his shifts. The necessity of the automatic collision avoidance system, therefore, became the biggest challenge to scholars over the world, especially when the marine transportation has been developing day by day and altering to the core of international trade. The ship domain has been known as the dramatically effective method for this system in order to estimate the risk of collision (CR) and to define the dangerous area around the ship. Historically, the first domain has been known as a shape of the circle of which the center will be placed at the ship's position. Such circle is the main factor for calculating the distance of the closest point of approach (DCPA) and the time remaining to reach this point (TCPA), which are two parameters used effectively in estimating CR and making a decision of avoiding collision. Obviously, the terms DCPA and TCPA are more concerned and commonly used. In addition, to develop the ship domain, Fujii (Fujii, 1971) introduced an ellipse domain and Goodwin (Goodwin, 1975) proposed three segments of the circles created by different radius, not to mention the fact that both of them have been widely applied since the 1970s in marine traffic engineering. The following step can be illustrated briefly by numerous researches of: Davis et al. (1980, 1982); Coldwell (1983); Zhao et al. (1993), Zhu et al. (2001), Smierzchalski (2001), Kijima and Furukawa (2001, 2003), Pietrzykowski (2004, 2006, 2008), Szlapczynski (2006), etc. The existing domains have presented various shapes and sizes taking into account of different factors. Those which are considered in determining the parameters of ship domain can be listed as ship size, ship's maneuvering characteristic, sea state, hydrological conditions, meteorological conditions, ship's velocity, relative ship's speed, traffic intensity, the knowledge of navigator, the factors – related variety make the definition of ship domain complex. On the whole, the previous researches were divided into two trends due to the function of domain: the first one requires the dangerous area that other vessels have to keep clear and the second plays vital role in risk assessment. This paper introduces a new concept of the ship domain, including two parts: "Blocking area" and "Action area", besides, the first function mentioned is considered, the second function is really removed and replaced by using DCPA and TCPA. Additionally, the methods of determination and configuration of the domain will be analytically described in order to point out the advantage of such methods.

II. Previous ship domain

The concepts of ship domain were described early from the 1960s and altered to one of the most attractive potential fields, proved by numerous researches over the past 50 years. The advantages of ship domain include quickly identifying and evaluating the navigation situation. Apparently, it plays a key role in assessing CR and generating the decision of the maneuver. The previous studies have been distinguished into three groups, containing statistical, analysis and artificial intelligence methods.

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