Study on the Safe Speed of Very Large Vessel in Complicated Waters

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1. Introduction

The size and speed of new vessels are constantly increased. It reduces vessel manouevrability and making the waterways more congested. Navigation, especially very large vessel in restricted water, has become more and more complicated and dangerous. To prevent these major causes of collision, proper training of vessel manning for vessel operator must be the prime consideration to avoid accidents at sea. Knowledge, technical ability and experience are essential elements for a qualified vessel operator to manoeuvre a vessel to prevent collisions.

This paper attempts to determine vessel’s safe speed by learning experienced vessel safe speed maker based on intelligent algorithms.

2. Safe Speed Decision-making Scheme

Safe speed decision-making depends on not only the vessel itself but also circumstances around the vessel. The ColRegs set out factors to be taken into account for all vessels and vessels with operational radar. In determining a safe speed the following factors shall be among those taken into account: Visibility; traffic density including concentrations of fishing vessels or any other vessels; manouevrability of the vessel with special reference to turning ability in the prevailing conditions; the presence of background light at night such as from shore lights or from back scatter of her own lights; the sea state; proximity of navigational hazards; the draft in relation to the available depth of water, and so on.

The safe speed decision-making index becomes larger with the higher the speeds. For understanding the relationship among the safe speed decision-making indexes, and conforming to experienced safe speed decision maker thought, each index should be non-dimensionalized firstly. Each index value is then set within [0, 100]. It means the factor influence the safe speed worst as the index value is 0, the corresponding safe speed is valued smallest. To the contrary, the corresponding safe speed is valued biggest when the index value is 100. Very large vessel safe speed is decided in accordance with the 5 indexes values and their respective index weights. To decide the vessel safe speed precisely, all information must be overall considered by an effective information fusion scheme.

3. Off-line Learning Algorithms

Here neurofuzzy method is applied as the off-line learning algorithms to fuse the multi-source navigational information. To collect the training data set, some experienced vessel safe speed maker such as senior port pilots and captains are consulted. A Fuzzy Inference System (FIS) and the initial FIS parameters are constructed in accordance with vessel operation experience. The FIS parameters are adjusted by use of neuro network learning algorithms. Through each case, a set of data \((a_1, a_2, a_3, a_4, a_5, v)\) is collected. \(v\) is the safe speed. To construct the FIS, initially the membership functions for \(a_1, a_2, a_3, a_4, a_5\) are assigned a form. The fuzzy logic system with its interpretative linguistic rules cannot learn. Hence the neural networks are utilized as the learning algorithms to create fuzzy logic inference from training data sets. Here the Sugeno-type (Sugeno 1985) is adopted for FIS. To update the parameters of the fuzzy inference system, a combination of the least-squares method and back-propagation gradient descent method is applied (Jang 1993). Here the selected training data set consists of a processed number of data sets consisting of \(a_1, a_2, a_3, a_4, a_5\) and \(v\) values.

4. Applications

This approach is applied to the problem of a very large vessel safe speed decision-making model in Guangzhou Bay of Zhanjiang port to verify the proposed scheme. First, senior pilots of Zhanjiang port provide the data set for the training sample by questionnaire. Then the data set is learned by use of neurofuzzy algorithm to refine the safe speed model. Finally, the safe speed model is tested practically. The results shows that it is quite close to the safe speed given by the senior Zhanjiang port pilots.

5. Results and Discussions

To improve very large vessel navigation safety in complicated water area, a safe speed decision-making scheme for very large vessel proceeding in complicated waters is developed in this paper. The scheme developed here provides decision support deck officers and pilots to make decisions of very large vessel safe speed in order to avoid vessel collisions and grounding. The application results show the scheme works well. It has good social and economic benefits.

The fuzzy method is used in this paper to process the uncertainty of the navigation information. The techniques of the decision level multi-source information fusion such as neurofuzzy algorithm are carried out to obtain a precise model. It is a creative thought to conclude the experts experience as rules to help the present and future work. It is also a good idea to learn the big data and obtain useful regulations. More training data will be corrected and more cases in different water areas will be studied in the future.

References