

2012 International Workshop on Information and Electronics Engineering (IWIEE)

An AIS data Visualization Model for Assessing Maritime Traffic Situation and its Applications

PAN Jiakai^{a, b, c}, JIANG Qingshan^{b*}, HU Jinxing^b, SHAO Zheping^c

^a*Fujian Key Laboratory of the Brain-like Intelligent Systems, Xiamen University, Xiamen, 361005, China*

^b*Shenzhen Institutes of Advanced Technology Chinese Academy of Sciences, Shenzhen, 518055, China*

^c*Navigation Institute, Jimei University, Xiamen, 361021, China*

Abstract

Correct appraisal of the marine traffic situation is important for safe shipping. However, the traditional maritime traffic survey and analysis are not good ready for easily indicating the dangerous shipping area. We propose a novel visualization model to appraise the maritime traffic situation based on Ship's Automatic Identification System. The rate of ship turn, speed acceleration and ship encounter are incorporated into a new index to indicate the relative dangerous shipping area. Our new model is applied to analyze the maritime traffic situations of Xiamen Bay and Meizhou Wan and proved to be practical and useful for maritime traffic decision-making and management of marine authorities and mariners.

© 2011 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Harbin University of Science and Technology Open access under [CC BY-NC-ND license](#).

Keywords: Maritime Traffic Situation; Ship AIS Data Visualization; Rate of Turn; Speed Acceleration; Ship Encounter

1. Introduction

The maritime traffic situation reflects the real condition of the marine shipping. Therefore the ship masters should have a good understanding of the maritime traffic situation for shipping safety. But the traditional techniques require much researcher's time and efforts and cannot provide the obvious and direct indication of shipping situation [1].

* Corresponding author Tel.: +86-755-896392340; fax: +86-755-896392340.

E-mail address: panjiacai@163.com and qs.jiang@siat.ac.cn.

Today an Automatic Identification System (AIS) was widely installed on board ships. The AIS is an automated tracking system used on ships and units ashore to identify and locate vessels by electronically exchanging data with other nearby ships [2]. The researches on AIS data cover most of the topics of maritime traffic [2-5, 8-10].

It should be known that a preliminary version of this paper appeared in [7], where we made an initial effort to explore the maritime traffic situations by combining our previous works. In this paper, maritime traffic situations are evaluated from a new perspective, and we design a new visualization model to show the actual maritime traffic situations directly and clearly.

2. An AIS Data Visualization Model

In this section, we design a new model shown in Figure 1 for the index of maritime traffic situation (Imts). This model combines three dynamic features, namely rate of encounter, rate of turn and speed acceleration from AIS data and the Imts is visualized on the Electronic Chart Display and Information System (ECDIS).

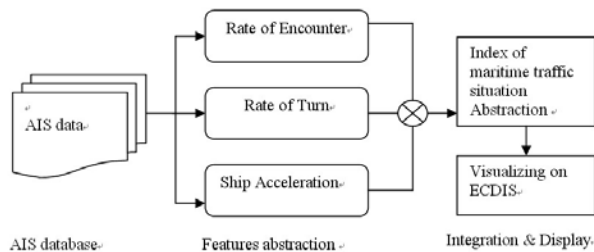


Fig. 1. The flowchart of AIS data visualization model

2.1. Rate of Ship Encounter

If the ships will encounter others closely and frequently and the potential dangers of collision or near miss will exist in the sea water. So the rate of ship encounters indicates the maritime traffic situation. In this paper, a ship's movement sequence in AIS data set is denoted by $A_{mmsi} = \{x_1, x_2, \dots, x_n\}$, where $mmsi$ is the unique ship identification, $x_i = (t_i, \lambda_i, \varphi_i, Co_i, Spa_i)$, t is the time stamp, λ and φ are latitude and longitude of ship position, The Co is the ship course and Spa is the ship speed. The distance for ship's encounter varies with the traffic situation in the sea area. This study looks into the port water, so the distance was set to 700 meters. As discussed above, the Rate of ship encounter is defined as follows:

Definition 1:

$$REnc = \frac{\text{Number of ship Encounter in grid}}{\text{Total of Ship Encounter}} \quad (1)$$

where the $REnc$ is the rate of ship encounter. Numbers of ship encounter in grid means the total numbers of ships within the small grid of sea area. Total of ships encounter means the total numbers of ships within the total sea area under consideration.

2.2. Rate of Ship Turn and Speed Acceleration

If there are many potential dangers or the marine environment is unsafe, ships should change dramatically their course or speed to keep away the sudden or potential dangers. As a result, the change rate of ship's course (ship's rate of turn) and speed (speed acceleration) imply the actual situation of the

marine environment. As discussed above, the ship's course and speed should be changed to reflect the ship's rate of turn (*RoT*) and speed acceleration (*SpA*), which are obtained as following formula:

Definition 2:

$$RoT = \frac{\text{Difference of Successive Course}}{\text{Time Intervals of Successive Record}} \quad (2)$$

Definition 3:

$$SpA = \frac{\text{Difference of Successive Speed}}{\text{Time Intervals of Successive Record}} \quad (3)$$

For better visualization and convenient calculation, *RoT* and *SpA* are the absolute value of definition 2 and 3 and their units are degrees per minute and knot per minute respectively.

2.3. Index of Maritime Traffic Situation

To better evaluate the maritime traffic situation, the rate of ship encounter and rate of ship turn and speed acceleration are incorporated into one index, namely index of maritime traffic situation (*Imts*). As discussed above, *Imts* is defined as follows:

Definition 4:

$$Imts = (\alpha \bullet REnc + \beta \bullet RoT + \gamma \bullet SpA) \quad (4)$$

where α , β and γ are the weight of the *REnc*, *RoT* and *SpA* respectively and fixed according to the research area or research purpose. In this study, α , β and γ share equal value, this means one third for each parameter. So *Imts* has following formula:

$$Imts = \frac{1}{3}(REnc + RoT + SpA) \quad (5)$$

According to above discussion, the algorithms for *Imts* visualization is designed as follow:

Algorithm: *Imts* Visualization

Input: AIS data

Output: *Imts* data set and visualization

Step 1: Segment the research area by meshing grids structure

Step 2: Select $A_{mmsi} = \{x_1, x_2, \dots, x_n\}$ within the research area into a new data set AISDB.

Step 3: Calculate $TimeDiff_i = t_{i+1}^a - t_i^b$, $LongDiff = \lambda_{i+1}^a - \lambda_i^b$ and $LatDiff = \varphi_{i+1}^a - \varphi_i^b$;

Step 4: Calculate distance $Dist = |x_i^a, x_{i+1}^b|$, if $TimeDiff < Tmax$, $LongDiff < \lambda_{max}$ and $LatDiff < \varphi_{max}$;

Step 5: Count an encounter if $Dist < EncDist$;

Step 6: Calculate and normalize *REnc* as definition 1;

Step 7: Calculate the *Rot* and *SpA* for every ships according to the definition 2 and 3;

Step 8: Normalize the *Rot* and *SpA*;

Step 9: Calculate *Imts* as definition 4.

Step 10: Visualize *Imts* in the ECDIS.

3. Experiments and Analysis

3.1. Experimental AIS Data

In this study, there are two AIS data sets from Chinese ports for our experiments [2]. The AIS data samples are obtained from the Integrated Vessel Information Service System [2] as shown in Table 1. The ship trajectories and *Imts* are displayed on ECDIS as shown in Figure 2 to Figure 5. It should be known that for better visualization, the results of *Imts* were amplified by 100 times and truncated to two-digit integers.

Table 1. Details of AIS data Samples

Port	Time duration	AIS data Volume	Ship Volume
Xiamen Bay	2010.10.1~10	865295	1669
Meizhou Wan	2009.11.1~10	649942	1546

3.2. *Imts* for Xiamen Bay and Meizhou Wan

In Xiamen Bay, the spatial distribution of *Imts* shows the actual condition of maritime traffic within the specific area. Those sea areas around areas A, B, C and D are more complicated as shown in Figure 3 and need more attentions from marine authorities and shipping for a safer navigation passage. This result is consistent with the true traffic situations within Xiamen Bay.



Fig. 2 Distribution of ship tracks of Xiamen Bay

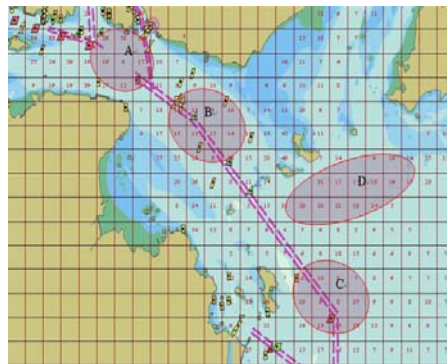


Fig. 3. Distribution for *Imts* of Xiamen Bay

In Meizhou Wan, the *Imts* of three areas is relatively bigger, as shown in Figure 5 and indicates the complicated traffic situation and may pose a potential danger to shipping. According to the survey, these results conform to the true traffic situation and give useful reference to the mariners and shipping authorities.

4. Conclusions and Future Work

In this paper, we propose a novel AIS data visualization model for visualizing the actual maritime traffic situation. To get better results, the *Imts* is composed by combining the rate of ship encounter, rate of turn and speed acceleration. The experiments on AIS collected from the Xiamen bay and Meizhou

Wan successfully visualize their situations of maritime traffic respectively. These conclusions conform to the fact and are useful for the maritime traffic decision-making and management of marine authorities. But in our future work, this visualization model should be improved by more theoretical analysis and experiment evaluation.

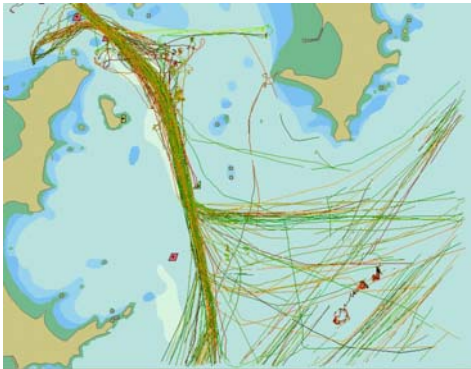


Fig. 4. Distribution of ship tracks of Meizhou Wan

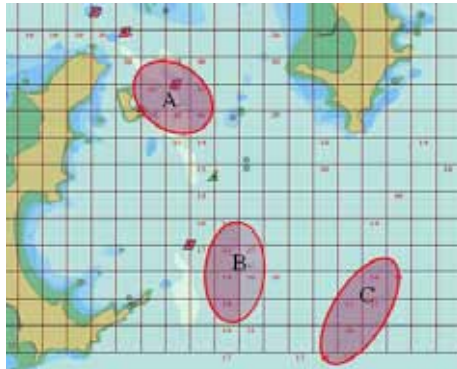


Fig. 5. Distribution of Imts of Meizhou Wan

Acknowledgements

This work is supported by the Shenzhen New Industry Development Fund (No.CXB201005250021A) and Scientific Research Project of the Education Department of Fujian Province (No. JA11155).

References

- [1] WU Zhaolin, ZHU Jun. *Marine Traffic Engineering (Second Edition)* (In Chinese). Dalian: Dalian Maritime University Press .2004.
- [2] SHAO Zheping, SUN Tengda, PAN Jiakai. Development of the Integrated Vessel Information Service System Based On ECDIS and AIS (In Chinese) [J]. *Navigation of China*, 30 (2), (2007)30-33.
- [3] Karl Gunnar Aarsaer and Torgeir Moan. Estimating Navigation Patterns from AIS, *The Journal Of Navigation*, 62, (2009)587-607.
- [4] Tsou, Ming-Cheng. Discovering knowledge from AIS database for application in VTS. *Journal of Navigation*, 63 (2010) 449-469.
- [5] Chang, S. J.. Development and Analysis of AIS Applications as an Efficient Tool for Vessel Traffic Service. *Proceedings of MTIS/IEEE TECHNO-OCEAN 2004*, 4, 2249-2253.
- [6] Dahlbom, A. and Nuklasson, L.. Trajectory Clustering and Coastal Surveillance. *Proceeding of 10th International Conference on Information Fusion*, FUSION 2007:1-8.
- [7] PAN Jiakai, JIANG Qingshan, SHAO Zheping. New Method to Appraise the Maritime Traffic Situations. *Proceedings of ICTE 2011*, ASCE: 315-321.
- [8] Yao, C., Liu, Z. and Wu, Z.. Distribution Diagram of Ship Tracks Based on Radar Observation in Marine Traffic Survey. *The Journal of Navigation*, 63(1), (2010)129-136.
- [9] Zheng, B., Chen, J., Xia, S. and Jin, Y.. Analysis of Marine Traffic flow Characteristics Based on Data Mining (In Chinese). *Navigation of China*, 32(1), (2009) 60-63.
- [10] Dahlbom, A. and Nuklasson, L.. Trajectory Clustering and Coastal Surveillance. *Proceeding of 10th International Conference on Information Fusion*, FUSION 2007:1-8.