Collision Preventing System of Marine Navigation using AIS System

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ABSTRACT

Navigation safety has become one of the important issues to the entire world community. Automatic Identification System (AIS) firstly has been used to comply with safety and security regulations, functioning as collision avoidance, vessel traffic services, maritime security, aids to navigation, search and rescue and accident investigation. This paper presents marine navigation collision preventing system between ships and ships using AIS. In the system, the raw data from AIS is crossed with database based MMSI number to find detail information then, location of each ship was plotted on to Google Map. The safety distance is assessed based actual and stopping distance. The system was tested in the Batam and Singapore Channel.

KEY WORDS: *Marine Navigation; Collision Preventing System, Automatic Identification System; Safety Distance.*

1.0 INTRODUCTION

Safety on navigation between the vessels has become one of the important issues to the entire world community. Shipping accidents have occurred more frequently which is attributed to heavy traffic in the strait between Batam, Indonesia and Singapore. The incident highlights the risk that ships face when navigating increasingly crowded in the strait. Over 100,000 oil and cargo vessels travelled the strait in a year, each day carrying 3.23 million barrels of crude oil which is about 33 percent of global seaborne crude oil. It was recorded 476 casualties from 1975-1995. These involved collisions (21 %), fire and explosion (17 %), sinking (32 %), engine troubles (26 %) and other (4 %) (Jaswar, 2013).

Automatic Identification System (AIS) firstly has been used to comply with safety and security regulations, functioning as collision avoidance, vessel traffic services, maritime security, aids to navigation, search and rescue and accident investigation. The AIS system is meant to be used primarily as a means of lookout and to determine the risk of collision rather than as an automatic collision avoidance system, in accordance with the International Regulations for Preventing Collisions at Sea.

The AIS was developed as a collision avoidance tool to enable commercial vessels to 'see' each other more clearly. The AIS does this by continuously transmitting a vessel's identity, position, speed and course along with other relevant information to all other AIS equipped vessels and port authorities within range. AIS was made compulsory in 2002 for most large commercial ships in which ships over 300 gross tonnage engaged on international voyages and cargo ships over 500 gross tonnage not engaged on international voyages and passenger ships irrespective of size.
This paper discusses development of marine navigation collision avoidance system using AIS data for safety navigation. The system is applied in the strait between Batam, Indonesia and Singapore as case study. The safety is assessed based on stopping distance and actual distance.

2.0 MARINE NAVIGATION TRACKING USING AIS

Marine traffic in the strait between Batam, Indonesia and

Singapore is analyzed using AIS data. The AIS system consists of an antenna, a splitter SS500, two AIS receivers SR 161 and FA30, Rectifier Unit PR-62L, converter RS-422, TP-Link (TESF1005D) and PC computer as shown in Figure.1 Primary data of ships which is obtained from an AIS receiver contains received date and time, message ID, MMSI number, IMO number, the position of the ship in term of longitude and latitude, speed of ground. The collected AIS data is simultaneously stored and updated in a hard disk on the Personal Computer. The raw data was recorded in every one minute which depends on setting up.

Figure 1: AIS System.

As an analysis collision prevention system will generate a huge number of calculations and result due to ship movement. In order to solve the problem, a program using Microsoft Visual Studio 2010 program was developed. In the program, the ship traffic patterns are evaluated using AIS data by crossing with ship database based on MMSI number to find detail of ships such as principle dimension, deadweight, gross tonnage, flag, type of ships, year built. Another data have been taken by the program from the ship database that have been created and save in the particular record. Figure.2 shows an example of ship detail recorded in a minute in the strait between Batam, Indonesia and Singapore. The ship traffic patterns are useful when evaluating ship operation modes, such as maneuvering, hotelling, and cruising.

Navigation tracking, often with a map in the background, but showing where the vessel have been and allowing to be preprogrammed, giving a line that can follow on the screen. In this programming, the marine navigation tracking shows the track of the ship using the AIS raw data that have been put in the program. The marine navigation tracking will show the position of the ship and denoted with different color based on the type of the ship. This kind of information can be detected by the program using the ships database that has been develop. That is the reason why the ship database is really important because of this matter. If the information in the database in not complete, perhaps the program cannot calculate at all the safety distance of the particular ship. The information that is very important such as the length of the ship.

Figure 2: An example of marine navigation tracking in a minute.

By using the longitude and the latitude, the position of the ships can be detected by plotting on map which is linked to Google map. Each type of ship is displayed in different colored for recognition easily. In this software, there are 31 types of ship recorded in the database. Percentage of each ship is displayed into pie chart and list view as shown in the Figure 3.

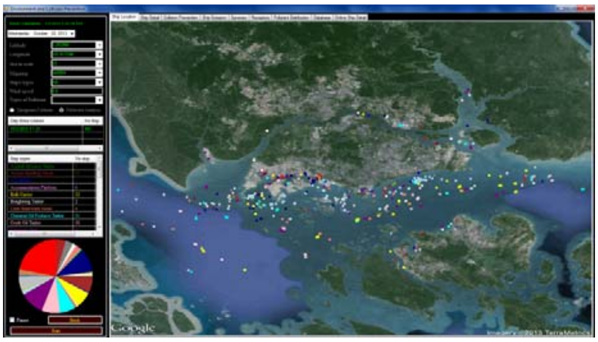

Figure 3: An example of marine navigation distribution in a minute in the strait between Batam, Indonesia and Singapore.

Figure 4 shows number of ships tracking by AIS in 2-October from 2003 to 2013 in which monthly, the average is 989 ships passed through the strait of Batam, Indonesia and Singapore. Marine traffic slowly increases to peak season at 7.00 am - 8.00 am, and then decreasing to normal condition at 10.00 am – 11.00 am until 9.00 pm before decreasing to lowest point at midnight as shown in Figure 5.

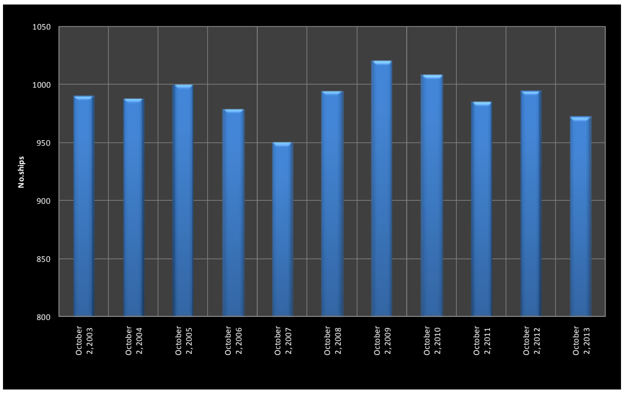

Figure 4: Number of ships passed through the strait between Batam, and Singapore in 2003 - 2013 tracking by AIS.

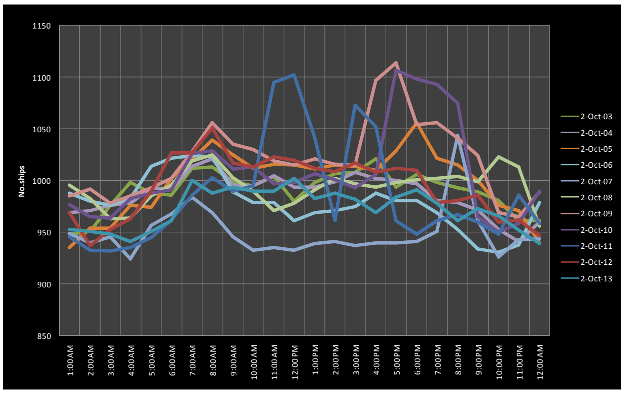

Figure 5: Number of ships hourly passed through between Batam, and Singapore on 2-October, 2003 - 2013 tracking by AIS.

3.0 COLLISION PREVENTING SYSTEM

3.1 Stopping Distance

The quantitative calculation of a ship's inertial stopping distance plays a very important role in the ship engineering field. Especially for the restricted is as such as bridge water area, the reversing stopping distance of a ship needs to be predicted accurately by quantitative calculation of the motions of a ship. The stopping and reversing stopping distance can be calculated by many different methods currently. Empirical equations are adopted by Ship's Handling. However, these theory equations do not consider the practice deeply in the calculation. Hence, the calculation result to some degree is inaccurate. More sophisticated methods is needed to handle this issue (Hirt et al., 1974; Jing, 1984; Wu, 1988; Liang et al., 2011; Barrasa et al., 2012). In order to provide precise prediction performance of ship's inertial stopping distance, this study introduces an ALE (Arbitrary Lagrangian Eulerian) algorithm to improve the prediction accuracy. The prediction result is compared with the physical model tests and related empirical equations to show high effectiveness of the proposed method.

Numerous observations (International Oil Tankers Commission, 1974) have been made concerning the stopping distance (D) of the ships in function with their speed. The principle results of maneuvering trials carried out in the fully laden condition of vessels ranging from 20,000 to 200,000 Deadweight are recorded for an initial speed of the ship 5 knots. In conclusion from observation made in Le Havre include the following:

1. The stopping distance, D will not be less than 5 times the length, L of the ship.
2. For the speeds, V exceeding 2.5m/s or 5 knots, the sopping distance is given by formula:

$$D = 4L\,[V/2.5]^{3/4} + L \qquad (1)$$

3.2 Actual Distance between Ships

The actual distance between ships is determined by using the Haversine formulation. The Haversine formula expressed in terms of a two-argument inverse tangent function to calculate the actual distance between two points on the Earth as follows:

$$d = R\,c \qquad (2)$$

where R is radius of the earth (6373 km) and

$$c = 2.\,atan(\sqrt{a}, \sqrt{(1-a)})$$

$$a = (\sin(\frac{\Delta_{lat}}{2}))^2 + \cos(lat_1).\cos(lat_2).(\sin(\frac{\Delta_{long}}{2}))^2$$

$$\Delta_{long} = long_2 - long_1$$

$$\Delta_{lat} = lat_2 - lat_1$$

3.3 Safety Distance Assessment

After determining the actual and stopping distance and heading angle for the particular vessel, the status of safety on navigation for that particular vessel with the other vessel will be identified. If the value of stopping distance is less than 5 times length of the ship, it can be concluded that that particular vessel is in danger condition. But before that the value of safety distance for the particular ship will be compare with the actual distance of the ship base on the longitude and latitude of that particular ship provided from the automatic identification system (AIS) data.

From the collision avoidance analysis, safety distance for the target ship and also the actual distance of the target ship with own ship is presented. As it can see in Figure.6, there are few ships probably in danger condition and the detail of danger ships will be displayed automatically.

Status of each ship whether it is in danger or not, do not depend on the distance between ships only. If the actual distance between the target ship and the own ship less that the safety distance, the ships can be consider in the dangerous condition. But it is depend on the situation also. That is why there is the reference from the website in order to consider what type of the vessel they are. For example if the target ship is tug boat, it does not matter because the tug boat maybe in process of assisting the target ship. In other words, if confirmed that the vessel is in danger condition, the information of that particular vessel can be forwarded to enforcement agency such as Marine Department of Malaysia (MARDEP) or Malaysian Maritime Enforcement Agency (MMEA). The information can be forwarded to enforcement team such as IMO number, calling-sign and other information. The additional information from website is used to determine what type of ship engaged with the target ship and it means the closest ship. Not all the value of actual distance of own ship with the own ship less that the safety distance of the own ship is in dangerous condition. With the website linked through the internet, the real identity of the ship with the picture can be identified no matter the own ship or the target ship.

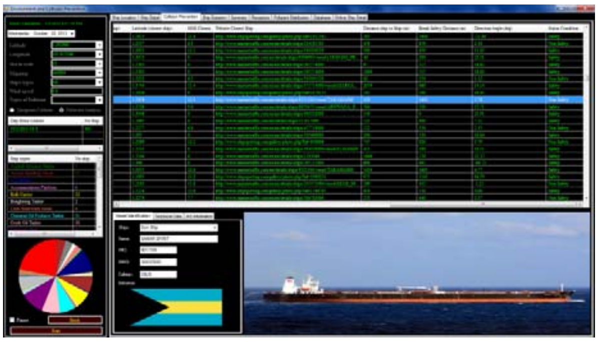

Figure 6: Results of safety assessment of marine navigation

4.0 CONCLUSION

Collision preventing system for marine navigation was developed by using data from the Automatic Identification System (AIS). The safety is assessed based on the safety distance and actual distances of the own and target ships. The safety and actual distances are calculated using International Oil Tankers Commission, 1974 and the Haversine formulation, respectively. This study showed that calculation of safety distance is able to cover all speed more than 5 knots.

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REFERENCES

1. Aarsaether. K.G., Moan.T.,(2009). Estimating navigation patterns from AIS. Journal of Navigation. Vol. 62 pp. 587-607.
2. Barrasa, G., M. Soulib, N. Aqueletc and N. Coutyd, 2012. Numerical simulation of underwater explosions using an ALE method: The pulsating Bubble phenomena. Ocean Eng., 41: 53-66.
3. Chua, T. E., Natarajan, R. and Ross, S. A. (1998) Analysis of the state of the marine environment of the Straits of Malacca and Singapore. Singapore Journal of International and Comparative Law 2, 323 - 349.
4. Development and Analysis of AIS Applications as an Efficient Tool for Vessel Traffic Service, 2004
5. Graveson. A., (2004). AIS – an inexact science. Journal of Navigation. Vol. 57(3) pp. 339-43.
6. Gucma. L., Przywarty. M., (2007). The model of oil spills due to ships collisions in southern baltic area. In Advance in marine navigation and safety of sea transportation, Proceedings from the 7th International symposium on Navigation (pp. 593-597). Gdynia, Poland.
7. Gucma. L., Goryczko. E., (2007). The implementation of oil spill costs model in the southern Baltic sea area to access the possible losses due to ships collisions. In Advance in marine navigation and safety of sea transportation, Proceedings from the 7th International symposium on Navigation (pp. 583-585). Gdynia, Poland.
8. Hamzah, A. (1997) The Straits of Malacca: A Pro®le. In The Straits of Malacca: International Co-operation in Trade, Funding and Navigational Safety, ed. A. Hamzah, pp. 3±14. Kuala Lumpur, Pelanduk Publications (M) Sdn. Bhd. and Maritime Institute of Malaysia, 359pp.
9. Harre, "AIS in VTS- the impact on the equipment composition and on day-to-day operations", Proceedings of lSlS 2002 of DGON, September 2002.
10. Hendra Saputra, Adi Maimun, Jaswar Koto, Mohammad Danil Arifin, 2013, Estimation and distribution of Exhaust Ship Emission From Marine Traffic in The Straits of Malacca and Singapore Using Automatic Identification System (AIS) Data, The 8th International Conference on Numerical Analysis in Engineering, Pekanbaru, Indonesia, pp.131-142.
11. Hirt, C., A. Amsden and J. Cook, 1974. An arbitrary lagrangian eulerian computing method for all flow speeds. J. Comput. Phys., 14(3): 227-253.
12. H.M Ibrahim & Mansoureh. Sh, Analysis of Carrying Capacity and Critical Governance Strategies for the Straits of Malacca, Maritime Institute of Malaysia.
13. IMO Resolution MSC.74 (69). "Recommendation on Performance Standards for A Universal Shipborne Automatic Identification System (AIS)".
14. IMO (International Maritime Organization).1998. IMO Resolution MSC.74 (69). "Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS)".
15. IMO (International Maritime Organization. 2003. Guidelines for the Installation of a Shipborne Automatic Identification System (AIS).
16. ITU-R Recommendation M.1371-1, "Technical Characteristics for a Universal Shipborne Automatic Identification System Using Time Division Multiple Access

in the Maritime Mobile Band.”
17. Jaswar, M.Rashidi and Adi.Maimun, 2013, Tracking of Ships Navigation in the Strait of Malacca Using Automatic Identification System, Developments in Maritime Transportation and Exploitation of Sea Resources, Taylor & Francis Group, London, pp.716-725.
18. Jaswar Koto, Safety on Navigation in The Strait of Batam-Singapore using AIS Data, AIS Workshop, 2013, Johor, Malaysia.
19. Jing, C., 1984. Theory of Ship Handling. China Communications Press, Beijing.
20. K. Ouchi, Making the Straits Safer: A User’s View of Alternative Routes (1994)
21. Liang, L., P. Xun and C. Wan, 2011. Study on underwater explosion shock characteristic of rudder based on ALE method. Proceeding of the International Conference on System Science, Engineering Design and Manufacturing Informatization, pp: 114-118.
22. M.Rashidi, Jaswar Koto and A.Maimun, 2013, Prediction of CO_2 Emission Caused by Marine Transport, AIS Workshop, 2013, Johor, Malaysia.
23. Mokhtari. A. H., Wall. A., Brooks. P., Wang. J., (2007). Automatic Identification System (AIS): data reliability and human error implications. Journal of Navigation. Vol 60(3) pp. 373-389.
24. Navigational Risk Assessment in Restricted Waters by Using AIS Data, 2010
25. Usage of Automatic Identification System (Ais) For Evaluation of Marine Traffic Safety In The Malacca Straits, 2010
26. Ross, A., Lintu, S. and Hachmoller, B. (1995) Navigational safety in the Malacca Straits. Tropical Coasts 2 (1), 7±10.
27. Shaw, K. E. (1973) The Straits of Malacca: in Relation to the Problems of the Indian and Pacific Ocean University Education Press, Singapore, 174 pp.
28. Wu, X., 1988. Ship's Maneuverability and Sway. China Communications Press, Beijing.
29. Xiaobo. Qu., Qiang. M., Li. S., (2011). Ship collision risk assessment for the Singapore Strait. Accident Analysis and Prevention. Vol. 43 pp. 2030-2063.