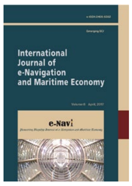
e-Navi

Available online at http://www.e-navi.kr/
e-Navigation Journal



Original article

A New Approach to Predict Fishing Areas Based on Historical Data☆

Geonung Kim[a*], Gyei-Kark Park[b]

[a*] Dept. of Computer Engineering, Mokpo National Maritime University, Korea, kgu@mmu.ac.kr, Corresponding Author

[b] Dept. of Logistics and Maritime Studies, Mokpo National Maritime University, Korea, gkpark@mmu.ac.kr

Abstract

The first stage of the SMART-Navigation project was completed in 2020, and a new project that aims to develop smart AtoN (aids to navigation) has begun. If the location information of ships is continuously collected, processed and accumulated, it will be possible to identify the behavioral characteristics of each ship and to combine the characteristics of active ships at some point to provide various forms of predictive information. In this paper, we describe how current and traditional fishing areas are identified based on the location information of fishing boats and then introduce a new method for predicting fishing areas in advance using historical information of currently active fishing boats.

Keywords: SMART-Navigation Project, smart Aids to Navigation, historical data, Fishing area

https://doi.org/10.52820/j.enavi.2021.16.043

1. Introduction

The aim of the SMART-Navigation project is to expand IMO's e-Navigation concept to develop specialized services for Korean maritime traffic environment. The SMART-Navigation project has been completed the first stage in 2020[1][2]. A new project that aims to develop the smart AtoN(Aids to navigation) has begun in 2021. It consists of two key tasks: the advancement of smart AtoN facility based on multi-purpose platform and development of new AtoN services that based on Big Data and AI(Artificial Intelligence).

Various studies are continuing to increase safety at sea by utilizing data analysis and information technology. Various maritime anomaly detection studies have been conducted [3]-[12]. Based on location information of ships collected by the AIS(Automatic Identification System), etc., hydrographic information through the ENC(Electronic Navigation Chart), and environmental information collected by various sensors, many studies have been conducted to predict and warn collisions and groundings, automatically extract optimal routes, or avoid collisions on unmanned ships [13]-[30].

The SV1 service - NAMAS(Navigation Monitoring & Assistance Service) of the SAMRT-navigation project determines the risk of collision and the risk of ship grounding based on the location information of ships and other information that related to vulnerability and provides prior warnings[31]-[35].

Various knowledge acquisitions from historical data will be possible due to the long-term collection of various information related to maritime safety. In this paper, we explain the method to identify current and traditional fishing areas in the SMART-Navigation services, and present a novel method for predicting fishing areas based on accumulated historical information obtained from these processes.

This paper is organized as follows; Section 2 describes data characteristics for the SMART-Navigation services; Section 3 presents several methods to identify current and traditional fishing areas; Section 4 presents new approach to predict fishing areas based on each ship's historical data.

2. Data Characteristics for the SMART-Navigation Services

The GICOMS(General Information Center on Maritime Safety & Security) provides ship location information for the SMART-Navigation services. Figure 1 shows AIS data density in August 2017, and figure 2 shows more detailed view of southern sea [33]. We segment each region by 0.0025 degrees and color represent the region based on the number of data collected. If the amount of data was less than the minimum value, it was expressed in white and black if the amount of data was greater than the maximum value, and the values in between adjusted the components of red and blue showed a difference between pure red and highly mixed colors.

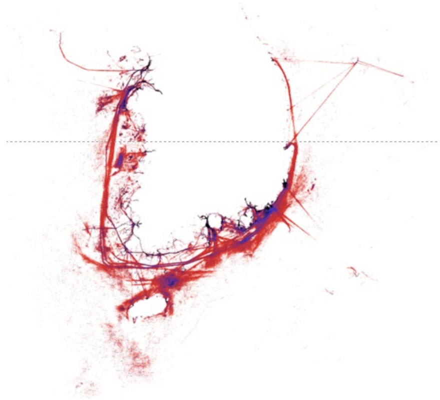


Figure 1: AIS position data density (08/2017) [33]

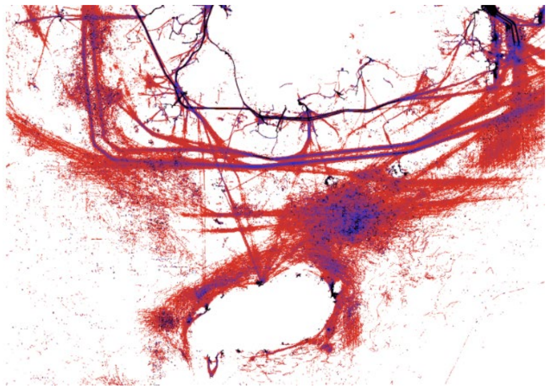


Figure 2: Detailed view of AIS position data density (08/2017) [33]

Figure 3 shows V-Pass data density in August 2017.

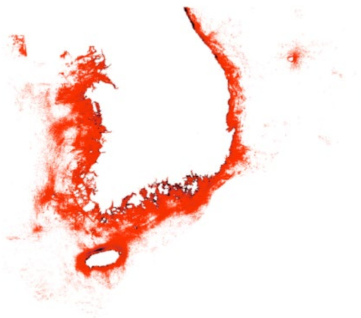


Figure 3: V-Pass position data density (08/2017) [33]

Table 1 shows the number of vessels classified by ship type from April 2017 to April 2018.

Table 1: Number of ships that reported by AIS (classified by type) (04/2017 ~ 04/2018) [35]

Ship Type	Identified	Reported
10 ~ 19(reserved)	95	73
20~29(WIG)	141	129
30(fishing)	20,557	20,271
31,32(towing)	350	339
33~36(diving, military)	484	455
37(pleasure)	1,819	1,814
40~49(HSC)	152	131
50(pilot)	123	116
51(SAR)	136	120
52(tug)	1,548	1,503
53~59(port tender, etc.)	444	424
60~69(passenger)	809	761
70~79(cargo)	21,727	21,462
80~89(tankers)	6,796	6,696
90~99(other)	1,162	1,111
Total	56,438	55,496

The number of fishing boats that reported its location using V-Pass was 48,993 in 2017. Therefore, nearly 70,000 fishing boats are operating in South Korean waters [35].

Table 2: Number of ships that reported by V-Pass (01/2017 ~ 12/2017) [35]

Ship Type	Identified	Reported
Total	73,461	48,993

The Table 3 shows the number of V-Pass reporting ships classified by tonnage in 2017. The figure 4 shows sea areas classified by the distance from mainland (and the Jeju island).

Table 3: Number of V-Pass reporting ships in sea areas (01/2017 ~ 12/2017) [33]

Tonnage	Area 2 (30 ~ 50km)	Area 3 (Over 50km)
Under 2 tons	209	7
2 tons ~ 5 tons	853	124
5 tons ~ 10 tons	2,078	886
10 tons ~ 20 tons	216	122
20 tons ~ 50 tons	957	833
Over 50 tons	672	604
unknown	67	24
Total	5,052	2,600

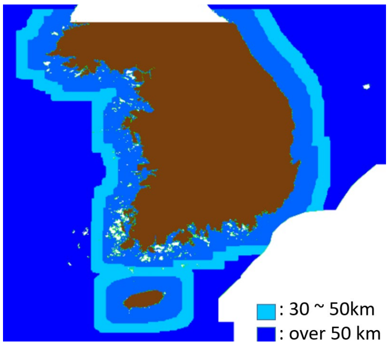


Figure 4: Sea areas [33]

3. Discovering Fishing area

In fishing vessels operating area, fishery, fishing line, trawl net and other fishing gears limit traffic performance and cause collision accidents and other accidents such as obstructing the route of other ships or netting the propeller. Because the route planning of the merchant ships is usually designed to avoid traditional fishing grounds and areas with dense fishing fleets, discovering the current and traditional fishing areas is one of the key functions of the SMART-Navigation services [38].

3.1 Identifying the Status of Fishing vessels

Fabio Mazzarella et al. proposed a method that automatically extracts knowledge from AIS data to discover fishing area. While in port, the ship has a very low SOG(Speed on Ground) and a COG(Course on Ground) that changes very rapidly. When the ship is steaming, its SOG is around 8 knots and its COG is almost constant. During its fishing operation, finally, both the SOG and COG change in a very random and fast manner [36]. We can estimate the status of fishing boats using these characteristics.

Various methods for identifying fishing areas have been tried and developed [37]. Figure 5 shows result of [37] from monthly data in Icelandic waters. They extracted tracks from all AIS positions and then extracted stops and moves by the events identification algorithm.

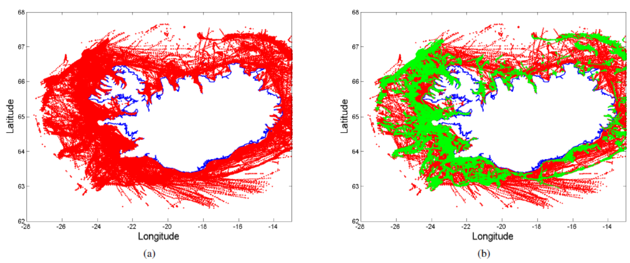


Figure 5: Fishing footprint of Iceland waters [34]

3.2 Identifying Current Fishing Areas

We first applied the method in [36] to remove the sailing vessels and then applied the Fuzzy C-Means clustering method to group the vessels to identify current fishing area [38]. Figure 6 shows the result of each process.

Figure 6: Discovering current fishing area [38]

3.3 Identifying Traditional Fishing Areas

Identification of traditional fishing areas goes through the following steps.

Step 1: Identification of current fishing areas

(1) Identifying the status (stopped/sailing/in fishing operation) of the vessel using location information collected in the last five minutes (COG standard deviation, current SOG, SOG mean value, SOG standard deviation, etc.).

(2) Composition of a zone with a density of over a certain size as convex hull

(3) Removing coastal areas such as port areas

(4) If necessary, it shall be displayed in the form of maps by area.

Step 2: Data Accumulation

Step 3: Identify traditional fishing areas from accumulated data.

Figure 7 shows the result of identifying traditional fishing areas by 2017's location information.

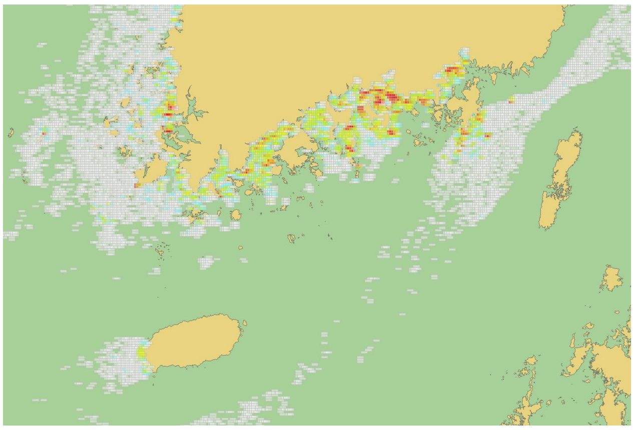


Figure 7: Identifying Traditional Fishing Areas (2017) [34]

4. New Approach to predict the fishing areas

If location information for each vessel is continuously collected and analyzed, it will be possible to identify the characteristics of each vessel's activities. When sufficient data are collected, each vessel's performance (average speed, maximum speed, etc.) and behavior characteristics (major activity areas, average sailing time, average fishing time, etc.) will be obtained, and it will be possible to predict the behavior of the vessel based on historical information of one day, one week, and one month. If this information is constantly analyzed and accumulated, more accurate behavior predictions will be possible.

Figure 8 shows sample case #1; identifying fishing areas by 1-day data. We can find 2 stopped points (E125.713 N34.572, E125.70 N34.63) and 3 rectangular fishing areas.

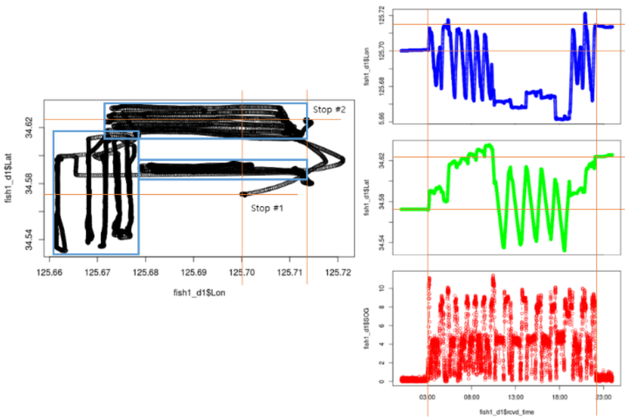


Figure 8: Identifying fishing areas by 1-day data [34]

Figure 9 shows sample case #2; identifying fishing areas by 1-month data. We can find 4 stopped points and 3 fishing areas.

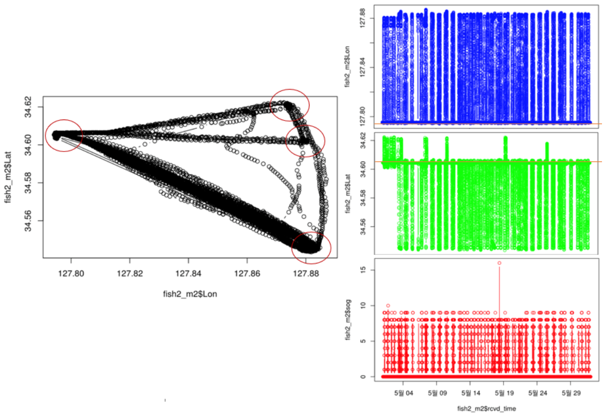


Figure 9: Identifying fishing areas by 1-month data [34]

Figure 10 shows sample case #3; identifying fishing areas by 1-year data. We can find several stopped points and several fishing areas. We can see several data errors in SOG graph. The performance data of this ship can be used to eliminate these invalid data.

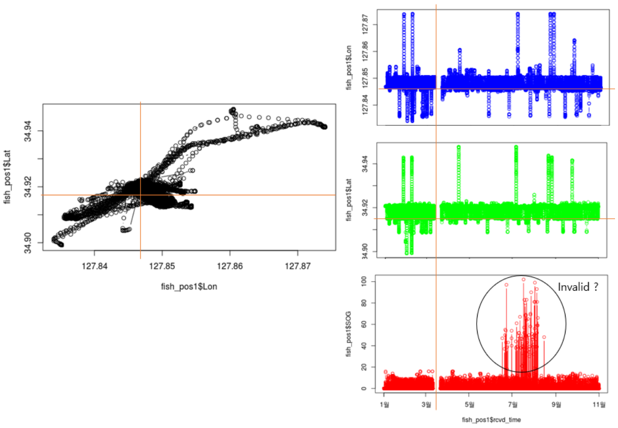


Figure 10: Identifying fishing areas by 1-year data [34]

In identifying fishing areas, collecting engine stopped locations for each fishing boat can be the most important task. Excluding port areas, the engine stopped points for each fishing boat can be either a fishing area or a resting area during fishing operation.

Information on each ship's fishing area should be stored efficiently. The information to be included is the coordinates of the stopped location and the number of stops, the geometric shapes of each region (circles, squares, etc.), and the associated values (length, angle, etc.). It also requires the ability to efficiently construct one large region by integrating adjacent regions. The ability to construct paths from a set of points and regions from a set of paths is essential.

For fishing boats, fishing area information can be the most important business secret. Therefore, for safety purposes, information on each fishing boat's activities can be collected and integrated to provide information on fishing areas to other commercial ships, but there should be the anonymity or de-identification process to prevent leakage of business secrets of individual fishing boats [39]. Fishing area information should be provided only to users who need it, thereby preventing misuse of information.

5. Conclusions

In this paper, we introduce a method to extract new knowledge by continuously collecting ship's location information collected by the SMART-Navigation services, especially fishing boat location information. Collecting and analyzing the location information of fishing boats over a long period of time to identify the characteristics of each vessel's activities enables more accurate forecasting of fishing areas and provides an opportunity to bypass those areas during the course design phase.

In the future, more sensor information will be collected when the smart AtoN is developed, and it is expected that new maritime safety services will be developed by combining them together.

Acknowledgements

This research is a part of the project titled “The advancement of smart aids to navigation facilities,” funded by the Ministry of Oceans and Fisheries, KOREA.

References

“SMART-navigation project”, http://smart-navigation.org/eng/html/Index_New (2021)

Han-Jin Lee, “SMART-Navigation: an e-Navigation project focusing on non-SOLAS ships as well as SOLAS ships”, http://www.iala-aism.org/content/uploads/2016/09/1110-Han-Jin-Lee-SMARTnNav-an-e-nav-project-focusing-on-non-SOLAS-vessels-v1.pdf, (2017)

Etienne Martineau, Jean Roy, “Maritime Anomaly Detection: Domain Introduction and Review of Selected Literature”, Defence R&D Canada (2011)

Mario Riverio, Giuliana Pallotta, Michele Vespe, “Maritime anomaly detection: A review", https://www.researchgate.net/journal/1942-4795_Wiley_Interdisciplinary_Reviews_Data_Mining_and_Knowledge_Discovery (2018)

Richard O. Lane, David. A. Nevell, Steven D. Hayward, Thomas W. Beaney, "Maritime anomaly detection and threat assessment", 13th International Conference on Information Fusion, Edinburgh, UK, 26-29 (2010)

Christoffer Brax, "Anomaly Detection in the Surveillance Domain", Örebro University, (2011)

Etienne Martineau, Jean Roy, "Maritime Anomaly Detection: Domain Introduction and Review of Selected Literature", DRDC Valcartier TM 2010-460 (2011)

Ines Obradović, Mario Miličević, Krunoslav Žubrinić, Machine Learning Approaches to Maritime Anomaly Detection", "Naše more" 61(5-6)/2014., pp. 96-101 (2014)

Mathias Anneken, Yvonne Fischer, J ¨ urgen Beyerer, " Evaluation and Comparison of Anomaly Detection Algorithms in Annotated Datasets from the Maritime Domain", pp. 169~178, SAI Intelligent Systems Conference (2015)

Maria Riveiro, Giuliana Pallotta, and Michele Vespe, "Maritime Anomaly Detection: A Review", WIREs Data Mining Knowledge Discovery, Advanced Review. 2018;e1266 (2016)

Dominik Filipiak, Milena Stró˙zyna, Krzysztof W˛ecel, Witold Abramowicz, "Anomaly Detection in the Maritime Domain: Comparison of Traditional and Big Data Approach", STO-MP-IST-160 (2017)

"Improving Maritime Situational Awareness – Through Big Data Analysis, Machine Learning and Artificial Intelligence", White paper, MarineTraffic Research (2019)

Philipp Last, Christian Bahlke, Martin Hering-Bertram, and Lars Linsen, "Comprehensive analysis of automatic identification system (ais) data in regard to vessel movement prediction," Journal of Navigation, vol. 67, no. 5, pp. 791–809, 2014. DOI:http://doi.org/10.1017/S0373463314000253

Clement Iphar, Aldo Napoli, Cyril Ray. Detection of false AIS messages for the improvement of maritime situational awareness. Oceans '2015, Washington, DC, United States. <hal-01203049> (2015)

J. Lisowski & M. M. Seghir, "The safe ship control with minimum risk of collision", Transactions on Ecology and the Environment vol 24 (1998)

"Józef Lisowski, "Computer Support Methods of Navigator Decisions Avoiding Accidents at Sea", X International Congress of the International Maritime Association of the Mediterranean (2002)

Ming-Cheng Tsou, Chao-Kuang Hsueh, "the Study of Ship Collision Avoidance Route Planning by Ant-Colony Algorithm", Journal of Marine Science and Technology, Vol. 18, No. 5 (2010)

Q. Li & H. S. L. Fan, "A Simulation Model for Detecting Vessel Conflicts Within a Seaport", TransNav Vol. 6. No. 1 (2012)

Bo Li, Fu-Wen Pang, "An approach of vessel collision risk assessment based on the D–S evidence theory" Ocean Engineering 74 (2013)

Piotr Borkowski, "Presentation algorithm of possible collision solutions in a navigational decision support system", Scientific Journals Maritime University of Szczecin (2014)

Shen Guangwei, et al., "A Study on Alarm System for Small Ship Safety Navigation in Ningbo-Zhoushan Port, ", Review of Graduate School of Maritime Sciences, Kobe University (2013)

Yihua Lin, Yingjie Xiao, "Risk Degree of Ship-bridge Collision based on Theory of Ship Collision Avoidance", International Journal of Control and Automation, Vol. 7, No. 11 (2014)

Zhaokun WEI, Kang ZHOU, Ming WEI, "Decision-Making in Ship Collision Avoidance based on Cat-Swarm Biological Algorithm", International Conference on Computational Science and Engineering, (2015)

ManhCuong Nguyen, Shufang Zhang, Xiaoye Wang, "A Novel Method for Risk Assessment and Simulation of Collision Avoidance for Vessels based on AIS", Algorithms 2018, 11, 204 (2018)

van Duong Nguyen, Rodolphe Vadaine, Guillaume Hajduch, René Garello, Ronan Fablet. Neural Networks for Vessel Monitoring Using AIS Streams. OCEANS'18 Charleston (2018)

J. Zhang, Q. Hu, "Ship Collision Avoidance Decision Model and Simulation Based on Collision Circle", TransNav Vol. 13, No. 2, (2019)

Enmei Tu, et al, "Exploiting AIS Data for Intelligent Maritime Navigation: a Comprehensive Survey", IEEE Transactions on Intelligent Transportation Systems, Volume: 19 , Issue 5, May (2018)

Michael R. Benjamin, Joseph A. Curcio, "COLREGS-Based Navigation of Autonomous Marine Vehicles", IEEE Xplore Conference: Autonomous Underwater Vehicles, IEEE/OES (2004)

Kyle Woerner, "Multi-Contact Protocol-Constrained Collision Avoidance for Autonomous Marine Vehicles", Ph. D Thesis, MIT (2016)

Jesus Mediavilla Varas, et al. "MAXCMAS project. Autonomous COLREGs compliant ship navigation", Proceedings of the 16th Conference on Computer Applications and Information Technology in the Maritime Industries

(COMPIT) (2017)

Geonung Kim, Jo-Chun Choi, Gyei-Kark Park, Taeho Hong, Do-Yeon Kim, Gi-Jeong Jo, "Survey on the Korean VMSs for Fishing Vessels and Challenge for Monitoring the High-risk Ships", e-Navigation Underway Asia-Pacific 2017 (2017)

Jo, G. J., Hu, Y.C., Park, G. K., Hong, T., Building of an Algorithm to Generate Ship's Collision Risk based on Accident Vulnerability under Bad Weather using Fuzzy Logic. Journal of Korean Institute of Intelligent Systems 28(4), 369–374 (2018)

Geonung Kim, Gi-Jeong Jo, Gyei-Kark Park, "Current Status of Real-time Monitoring Service to prevent Collision and Grounding in SMART-Navigation Project", Proceeding of Ai-Mast 2018 (2018)

Geonung Kim, Gi-Jeong Jo, Gyei-Kark Park, "Changes in the fishing vessels monitoring system due to the SV1 Service in SMART-Navigation Project", Proceeding of Ai-Mast 2019 (2019)

Geonung Kim, Gyei-Kark Park, Gi-Jeong Jo, "A New Approach for Improving Performance of the SV1 Service of the SMART-project", International Journal of e-Navigation and Maritime Economy Vol. 15, pp.1-9 (2020)

Fabio Mazzarella , Michele Vespe, Giacomo chato Osio, "Discovering vessel activities at sea using AIS data: Mapping of fishing footprints", 17th International Conference on Information Fusion(FUSION) (2014)

Fabrizio Natale, Maurizio Gibin, Alfredo Alessandrini, Michele Vespe, Anton Paulrud, " Mapping Fishing Effort through AIS Data", Article in PLoS ONE, (2015)

Yancai Hu, Gyei-Kark Park, Thi Quynh Mai Pham, "A Solving Algorithm of Navigational Collision Risk through Data Analysis of Fishing Vessel Activities", Journal of Data, Information and Management (https://doi.org/10.1007/s42488-019-00014-x) (2019)

ISO/IEC 20889:2018, "Privacy enhancing data de-identification terminology and classification of techniques"

Received **21 June 2021**

Revised **25 June 2021**

Accepted **25 June 2021**