Combining AIS data and fuzzy clustering to measure danger score of ships

Ketut Buda Artana

Dinariyana DP

Masroeri, Trika Pitana

(Citation)
Journal of maritime researches,1(1):33-41

(Issue Date)
2011-03

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/81004908

(URL)
https://hdl.handle.net/20.500.14094/81004908

Journal of Maritime Researches Vol. 1, No. 1 March, 2011: 33-41.

COMBINING AIS DATA AND FUZZY CLUSTERING TO MEASURE DANGER SCORE OF SHIPS

Ketut Buda Artana*
Dinariyana DP*
Masroeri, Trika Pitana*

ABSTRACT

Traffic density at the Madura Strait has been very potential in contributing several ship incidents. To measure the potential of incident, some researchers introduced a method of measuring the level of danger called danger score. This study is aimed to enhance the method in calculating danger score by identifying some variables that influence the value of the danger score and to determine the weight of each variable. Fuzzy clustering is utilized to group some data into a homogenous data and expert system is then applied to determine rules in making decision and determine the weight of each variable. The value of each variable is calculated from several data sources such as statistical data of ship incident in the period of 2001-2009, Indonesian weather authority (BMKG) and AIS data installed at the reliability and safety laboratory of ITS Surabaya. Five new variables are introduced to the nomenclature of the danger score, namely: wave height, speed over ground, course over ground, distance between ships and human error. This investigation found that distance between ships is the most significant variable that leads to ship incidents, having a weight of 0,318.

Keywords: Danger Score, Fuzzy, expert system, AIS, Madura Strait

* Dept. of Marine Engineering, Faculty of Marine Technology, ITS Surabaya, Email : ketutbuda@its.ac.id, kojex@its.ac.id, masroeri@its.ac.id

1. INTRODUCTION

Madura strait, where Port of Tanjung Perak is located nearby, is one of the busiest straits in Indonesia. This port serves domestic and international routes and the traffic considerably potential to incidents. Considering the facts, it is required to understand the level of danger/risk of the vessel pass along the strait. One of the alternatives is the introduction of the danger score, a measure of level of danger possessed by a vessel that subject to internal and external factors that may initiate vessel incidents.

Artana and Syarifudin (2009) utilized AIS (Automatic Identification System) data to determine the danger score by means of Analytical Hierarchy Process (AHP) method in determining the weight of each criteria/variable of the danger score. The danger score was then calculated by multiplying the weight of each criteria and its function value, as shown in equation 1. From that research, some approaches need to be re-evaluated, such as:

1. Weighting method by AHP seems to be quite subjective; hence, respondent needs to be carefully responding the questions.
2. Previous researches took to many assumptions in determining the danger score of vessels. As an example, distance between vessels as one variable of the danger score was brought with a weak numerical approach to represent the closeness of the distance.

This research investigates a quantitative approach in determining the weight of criteria constructing the danger score. This research further tries to re-calculate the weight of danger score criteria by incorporating fuzzy clustering method.

Artana and Syarifudin (2009) utilized AIS data to calculate the danger score by introducing a formula as below:

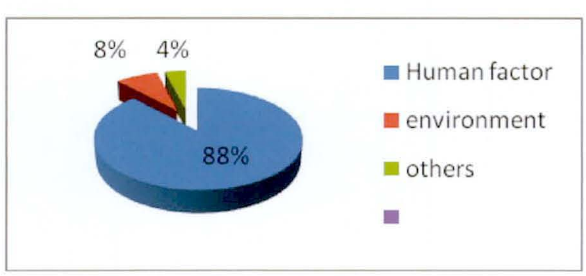
$$danger\ score = \sum_{i}^{n} Wifi \quad \text{.......} \quad (1)$$

Where

W_i = weight of each criteria

f_i = function values of each criteria

According to that research, human factor constitutes 88% of the vessel incidents as shown in Figure 1. Present paper classifies criteria into two groups, namely: quantitative and qualitative criteria.



Source : Mahkamah Pelayaran Indonesia

Fig. 1 Causes of vessel incident 2001-2005

Quantitative criteria can be directly calculated and compared. Ship dimension, distance between vessels, wave heights are some examples of quantitative criteria. Meanwhile, qualitative criteria need further description to be measured, such as noise, human error and others.

This research measures weight of each criterion by means of fuzzy logics through linguistic and numeric values. This paper proposes a method in solving several problems; (1) what criteria will affect danger score? (2) how to measure the weight of those criteria (3) how to incorporate the weight of each criterion into a single value of danger score, and (4) what is the main influencing criterion of the danger score?

2. LITERATURE STUDY

Various researches on ship safety operation have been carried out by so many researchers. Some researchers are focusing on enhancement of ship design, training, and ship management and then use them as part of formal safety assessment as well as regulations to manage seaworthiness of ships (Wang, 2001).

Vanem (2006) for many years has been focusing on design of effective evacuation when incident happen to passenger vessels. Other researchers converge on some points that power plant area and the area of engine room are locations that lead to accident the most (Podsiadlo and Tarelko, 2006). Safety and convenience of the engine room operators and the whole maintenance activities, hence, must be one of the priorities of attention.

Considering post accident management, Artana (2007, 2008, 2009) concluded that efforts must be focused on the way to train people (not only ship crews) in preventing marine hazard. One solution is by the provision of a simulation on marine hazard that can be used to compose a procedure in handling marine incidents, alongside with promoting safety culture to the society.

Number of ship incident in Indonesia from the year of 1999 until 2003 was still considerably high, as shown in Table 1. The source of incident can be summarized that ship sinking (31%), ship grounding (25%), ship collision (18,27%), fire (9,67%) and others (25,05%). The incident itself were caused by (78,45%) human error, (9,67%) technical problems, (1,07%) merely due to weather and (10,75%) due to combination of weather and technical problems. The peak of incident happened in 2001 with a total number of 102 incidents that led to a death casualty of 40 persons, as shown in Table 2.

Table 1 Ship incident in 1999-2003

No	Description	1999	2000	2001	2002	2003
1	No of incident	93	102	68	48	66
2	Loss of life	35	40	26	17	34
3	Human Error	150	843	657	58	46

Source : Directorate General of Sea Communication

Table 2 Source of incident

No	Description	Total
1	Leakage	1
2	Drifting	3
3	Construction problem	23
4	Engine failure	3
5	Grounding	1
6	Colliding berthing system	1
7	collision	20
8	sinking	63
9	capsizing	15
10	fire	27

Source : Directorate General of Sea Communication

Intensive investigation reveals that incompliance to regulations has been one of the most frequent initiations of ship incident in Indonesia. Furthermore, unawareness on safety management reporting system also leads to several casualties (incompliance to ISM Code), to one side of incompliance of technical requirements of the classification society.

This research introduces the utilization of fuzzy in determining danger score of vessels. Fuzzy concept was introduced by Profesor Lotfi Zadeh of the University of California in 1960s. Professor Zadeh introduced a mathematical formulation to examine uncertainties in a form of linguistic translation named fuzzy logic (Naba, 2007), as a successor of Crisp Logic. Fuzzy logic is a logic that posses a fuzziness between true and false value. In fuzzy logic theory, the weight of true and false will very much depend upon its membership function. By means of fuzzy logic, human expert system can be implemented in a very easy way. In a crisp set, membership of each element of a universal group can be classified into member and non-member of the group. This membership is assigned by a function named membership function, having a value of 1 for a member and 0 for a non-member. Membership function can have a membership value between 0 and 1.

If U represents a universal set and A corresponds to fuzzy set and subset to U, then A can be expressed as below:

$A = \{(u, \mu A(u)) | u \in U\}$ .... (2)

where $\mu A(u)$ stands for membership function with

$\mu A : U \rightarrow [0,1]$ .... (3)

Expert system is computer program that models expertise in many ways. This system generally consists of 2 main modules: knowledge base and inference engine. This system can sometimes be added with working memory. Expert system uses to converts facts compiled by the programmer into conclusions taken from inference process. Fuzzy expert system can be considered as expert system that can handle fuzzy data. One important parts of expert system is fuzzy set theory developed by Zadeh (1965) called Fuzzy Rule Based Systems (FRBSs). FRBSs itself consists of two components (1) inference system; translate inference fuzzy process needed to produce output from FRBSs by utilizing very specific inputs. (2) Knowledge base (KB); represents knowledge of problem to be solved obtained from manipulation of several fuzzy logics (Alcala, 1999). Fuzzy inference model of Mamdani was introduced by Ebrahim Mamdani in 1975. Output membership function is represented by several linguistic variables connected by fuzzy sets (Alcala, 1999). Inference process uses IF-THEN form, with a general form of IF X is A THEN Y is B. Expression of X is A called antecedent, and Y is A represents the value of linguistic variables as consequent. An IF-THEN rule can be constructed by several antecedent and consequent in the form of: IF X_1 is A_1 and ... and X_n is A_n THEN Y_1 is B_1 and ... and Y_m is B_m.

3. RESEARCH METHODOLOGY

This research is carried out through several steps as figured below. In this research, problem in determining danger score will be focused to a case study of Madura Strait. There are three criteria used within this research: (1) environmental condition, (2) human error, (3) vessel condition.

Fuzzy method applied in this research was a development of expert system through knowledge engineering as developed by Hayes-Roth (Fu, 1994). There are five stages comprised: identification, conceptualization, formulation, implementation, and verification. Data used here were wave height, wind speed (year of 2006-2008), AIS data 2008, and statistical data of marine incident in Madura straits from 2005 until 2009.

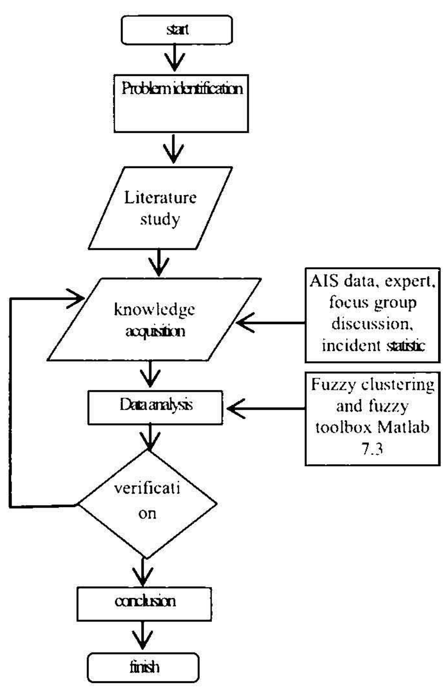


Fig. 2 Research sequence

4. DATA ANALYSIS

Assessment of the danger score incorporates several data such as wave height, wind speed obtained from BMKG Indonesia, AIS data obtained from AIS receiver installed at the laboratory of Safety and Reliability of ITS Surabaya, and record of ship incidents from Mahkamah Pelayaran Indonesia.

Some criteria used within this research: (1) wave height, (2) speed over ground, (3) course over ground, (4) distance between vessels, and (5) human error record.

After analyzing the above data, The data then clustered by means of fuzzy clustering utility of the MATLAB 7.3. those data were then used as input for fuzzy. Table 3 to Table 6 shows result of the clustering process.

Table 3 Data clustering of danger score

	Danger score		
	Low (DR)	**Medium (DS)**	**High (DT)**
Center	12,65	41,59	90,74
Min	9,5	27,39	67,1
Max	27,1	65,42	181,2

Table 4 Data clustering of wave height

	Wave height (m)		
	Low (GR)	**Medium (GS)**	**High (GT)**
Center	0,06	0,21	0,35
Min	0,00	0,15	0,29
Max	0,14	0,28	0,88

Table 5 Data clustering of speed over ground

	Speed over ground (knot)		
	Low (SR)	**Medium (SS)**	**High (ST)**
Center	0,071	7,62	13,015
Min	0,00	3,9	10,3
Max	3,8	10,3	52,2

Table 6 Data clustering of course over ground

	Course over ground		
	Low (CR)	**Medium (CS)**	**High (CT)**
Center	7,78	194,1	302,27
Min	0,00	101,1	248,4
Max	101	248,2	359,9

After clustering, the membership function of the input variables were then determined. This membership function was expressed in trimf function. This type of function consisted of three values: minimum value, medium value and maximum value. Fuzzy logic toolbox Matlab 7.3 was utilized to determine the membership function. Table 7 shows the membership function of each variable.

This research has developed 243 rules that consisted of 56 rules to set SAFE condition, 133 rules for AVERAGE condition and 54 rules for DANGER condition. According to those variables, it was found that:

a. Human error variable with fuzzy set "low" was affecting variable to the danger score with fuzzy set "SAFE"
b. Wave height variable with fuzzy set "Medium" and interval 0.75 – 1.5 meter, distance between vessels within fuzzy set "far" and interval 25L – 35L meter and human error with fuzzy set "low" were the affecting variables for danger score with fuzzy set "AVERAGE"
c. Wave height variabel with fuzzy set "high" and interval 1.5 – 3 meter and variabel

human error with fuzzy set "high" were affecting variables with fuzzy set "DANGER". Figure 3 shows affecting variables of each danger score.

Table 7 Membership function

	var	Fuzzy set	interval	Mem. Function
Input	Speed Over Ground	Low	0-3.8	Trimf
		Medium	3.8-10.3	Trimf
		High	10.3-52	Trimf
	Course Over Ground	Low	0-101	Trimf
		Medium	101-249	Trimf
		High	248-359	Trimf
	Wave height	Low	0-0,75	Trimf
		Medium	0,75-1,5	Trimf
		High	1,5-3	Trimf
	Dist. Between vessel	Close	0-15	Trimf
		Medium	15-25	Trimf
		Far	25-35	Trimf
	Speed Over Ground	Low	0-3.8	Trimf
		Medium	3.8-10.3	Trimf
		High	10.3-52	Trimf
	Human Error	Low	0-3	Trimf
		Medium	3-6	Trimf
		High	5-10	Trimf
Outpu	Danger Score	Safe	0-27	Trimf
		Medium	27-65	Trimf
		Alert	41-181	Trimf

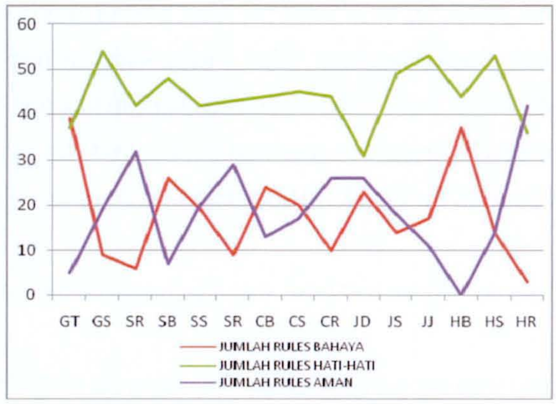


Fig. 3 Affecting variables of the Danger Score

Table 8 Normalized fuzzy values

	var	Fuzzy set	Xmin	Xmed	Xmax	Ave	Weight
Input	Speed over ground	Low	0	0,0014	0,073	1,8	0,081
		Med	0,0747	0,146	0,197		
		high	0,1973	0,2493	1		
	Course over ground	Low	0	0,0216	0,281	1,8	0,301
		Med	0,281	0,5402	0,69		
		high	0,690	0,8399	1		
	Wave height	Low	0	0,0682	0,159	1,8	0,133
		Med	0,170	0,239	0,318		
		high	0,329	0,3977	1		
	Dist. Betw. Vessel	Close	0	0,1429	0,429	1,8	0,318
		Med	0,429	0,5714	0,714		
		Far	0,714	0,857	1		
	Human error	Low	0	0,133	0,2	1,8	0,167
		Med	0,2	0,3	0,4		
		high	0,333	0,667	1		

Weight of each variables were then calculated after obtaining interval of each fuzzy set. The weights were obtained by nomalizing each fuzzy value: normalizing of minimum value (Xmin), normalizing of medium value (Xmed) and normalizing of maximum value (Xmax). Normalization was carried out by means of formula below:

$$\bar{X} = \frac{X - X_{min}}{X_{max} - X_{min}} \quad \text{..(4)}$$

Where:

$\bar{X}$ = normalized values
X = fuzzy value to be counted
X_{min} = smalles fuzzy value
X_{max} = bigest fuzzy value

REFERENCES

Alcala, R.J. Casilas, O. Cordon dan F. Hererra (1999) Approximate Mamdani-type Fuzzy Rule Based Systems: Features and Taxonomy of Learning Method, E.T.S de Ingenieria Informatica, Universidad de Granada.

Arifin Syamsul Aplikasi Sistem Logika Fuzzy pada peramalan cuaca di Indonesia, Institut Teknologi Sepuluh Nopember, Surabaya

Artana. Ketut Buda Development of simulation and reliability database for marine hazard, risk and maintenance management, Sepuluh Nopember Institute Technology of Surabaya

Artana, Ketut Buda (2006, 2007, 2008) Hibah Penelitian Pascasarjana, Pengembangan Perangkat Simulasi Marine Hazard untuk Keselamatan Transportasi Laut di Indonesia

Balakhrisnan, K. dan V. Honovar (1998) Intelligent Diagnosis Systems, *International Journal of Intelegent System* 10(1)

Direktorat Jendral Perhubungan Laut (2005) cetak biru pembangunan transportasi laut, Jakarta. Direktorat Jendral Perhubungan Laut , 2007, cetak biru pembangunan transportasi laut, Jakarta

Direktorat Jendral Perhubungan Laut (2006) Rekapitulasi kecelakaan kapal 2001-2005, Jakarta Fu. L, 1994, Neural Network for Computer Intelligent, Mc. Graw – Hill, Publishing, New York.

Kobayashi (2007) International Maritime Education and Research Center (IMERC), AIS Project Indonesia , Graduate School of Maritime Sciences, Kobe University

Naba .Agus (2007) Belajar cepat Fuzzy Logic menggunakan MATLAB, ANDI,Yogyakarta. National marine safety committee (2005), contributing factor in incidents, (www.nmsc.gov.au), diakses pada 2 Maret 2010 jam13: 00 WIB

Podsiadlo.Antoni dan Tarelko.Wieslaw (2006) Modelling and developing a decision-making process of hazard zone identification in ship power plants, Department of Engineering Science, Gdynia Maritime University.

Setyawan .Agung (2007) Aplikasi Metode Fuzzy dan MCDM dalam Pemilihan Motor Induk untuk Keperluan Repowering Kapal-Kapal TNI AL, Institut Teknologi Sepuluh Nopember, Surabaya

Syarifuddin Amin (2009) Kajian Penentuan Danger score Kapal Saat Berlayar Dengan Memanfaatkan Data Automatic Identifiation System (AIS)(Studi Kasus di Selat Madura), Institut Teknologi Sepuluh Nopember, Surabaya.

Surya Online, Uji model menjelaskan kecelakaan kapal, (www1.surya.co.id), diakses pada 2 Maret 2010 jam 10.00 WIB

Vanem. Erik dan Skjong. Rolf (2006) Designing for safety in passenger ships utilizing advanced evacuation analyses – A risk Based Approach, DNV Research

Wang (2001) The current status and future aspects in formal ship safety assessment, School of Engineering, Liverpool John Moore University.

Yuliasih.Indah.dkk, Desain perlakuan pasca panen terhadap kesegaran bunga potong lili dengan pendekatan sistem pakar fuzzy, Teknologi Industri Pertanian, IPB, Bogor.