Development of Simulation and Data Mining Concept for Marine Hazard and Risk Management

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ABSTRACT

This research is aimed to develop and evaluate essential technological and engineering hardware and software for encountering marine hazard as well as essential risk management system, covered organizers and human resources, which have proper judgment ability and leadership. This research is also directed to seek optimum alternative method to train and educate people to get knowledge and experience on hazard prevention. The simulation is also provided with a database system which eases the participant in performing their tasks. Response to each scenario will be optimized by comparing three (3) indicators, namely: cost, resources and time for task completion. At the end of the simulation, a formal procedure for the countermeasure can be designed which guarantee those three indicators are set to minimum. A data mining system is also attached to the simulation to enable the database in classifying the data according to the responses of the participants.

Key Words: Marine Hazard, Risk Management, Maritime Incident, Computer Simulation, Database, Data Mining

1. INTRODUCTION

Since the late of 1980’s, safety of ship operation has been a crucial issue. This was because there were so many poor management standards in shipping industries and shipping companies. Some of serious shipping accidents and incidents that have occurred could probably be referred to bad systems or insufficient or poorly executed maintenance. These are proved by the accident of Russian oil tanker MV NAKHODKA in January 1997 [1], which severely damaged the coast of all prefectures faced to the Sea of Japan. It is also still in our recall about the accident of MV PRESTIGE in the northern west of Spain in November 2002 [2].

Ahead of those above accidents, the International Maritime Organization (IMO) adopted guidelines on management for safe operation of ships and for pollution prevention known as International Safety Management (ISM) Code. The code was then adopted and incorporated in Chapter IX of the Safety of Life at Sea (SOLAS) regulation as amended by IMO on 24 May 1994. It entered into force by July 1st 1998 [3].

Apart from the availability of some ship safety regulations, shipping just like other industries, is susceptible to accidents, which result in regulations aimed at ensuring that similar incidents never happen again. However, bad accidents sometimes produce bad law. Law is not the best way to improve standards. Voluntary incentives often work better than legislative ones.

International Maritime Organization (IMO) has so far been producing several conventions with objective to ensure safety of ship operation and pollution prevention. Those conventions are MARPOL, SOLAS, ISM CODE, etc. In practice, however, implementations are rather exigent since some countries that ratified the conventions face so many difficulties due to mainly lack of fund and human resources [4, 5]. This even heavier when some small shipping companies tend to buy second hand ship, doing minimum modifications to comply with modern international regulation, and sometimes they treat that the machinery are new. This affects ship liability very much.

Indonesia, as the object of this study, has so far no integrated procedure to deal with problems resulted by marine hazards as well as procedure to localize affected area. If there is any, it considers the problem partially and only contemplates related party individually. This is mainly caused by lack of knowledge regarding anticipation efforts must be done to deal with the problem. To solve this problem, efforts in educating people for marine hazard prevention must be supported by chances to related party in marine hazard prevention to get experiences directly in such a circumstances, which enable them to play a certain role. This can be made possible by providing a computer simulation tool in which we could set up marine accident scenarios and each related party plays a role and has access to the server through a computer.
In marine hazard prevention, some parties are concerned. Those party covers Ship master, ship owner, maritime safety agency, salvage company, governor, port authority, fishermen organization, head of power station, fire brigade, police officer, surveyor, environmental agency officer, mass media, volunteers, experts, etc. This simulation is designed in such a way all parties exactly know its role and duty and know how to operate the simulation program. By means of Internet facility, an international scale simulation can be performed to experience problems in marine international law when an accident between two ships having different flag of registry occurs. This kind of simulation is believed to be very effective and valid to educate and train the participants who have not had experience and general of any kind of marine hazard within short period of time. Since cost of performing such kind of simulation is considerably low, then we may involve more participants without any obstacles in consuming too much budget.

This paper is a brief introduction of the progress we have been achieved within the framework of our long-term research programs.

2. STATE OF THE ART OF THE CURRENT RESEARCH

After the earthquake of Hanshin and Awaji in 1995 in Japan, a research group of Kobe University of Mercantile Marine has been performing a study on the optimum countermeasure against the large-scale natural or industrial hazards [7]. One of the basic subjects was related to technology and society, especially on risk management for the present society, which is supported and constructed by technological systems. As the implementation of this group’s program, after several ship incidents, the central and local governmental sectors and academic societies delivered an investigation on the reasons and countermeasure of the incidents. The research group has also proposed a modification on the present incident prevention system, in conjunction with proposition of the reinforcement scheme on the hazard prevention organizations.

The marine hazard research group of the KUMM has been studying the prevention manners and contingency measures system in maritime large-scale oil spill. Concurrently, hazards on industrial, social and natural cases have also been investigated. The current activities of this research group are mainly focused on three items:

1. The first, survey on essential technological and engineering hardware and software for encountering the hazard.
2. Second, survey on the essential risk management system, covered organizers and human resources, which have proper judgment ability and leadership.
3. Third, seeking optimum alternative method to train and educate students and people to get knowledge and experience on hazard prevention.

By taking this idea into account, a more effective method to train and educate people to get knowledge and experience on hazard prevention activities could also be performed in Indonesia for the benefit of safety ships operation and marine hazard prevention in Indonesia. This could also be developed by enlarging the research scope which providing chances to develop scenario that enables inexperienced people participate in the simulation of marine hazard prevention either with the cases of domestic accidents or incidents, or that of involving ships having different registry flag.

3. BASIC DEVELOPMENT CONCEPT

3.1 Marine Hazard Simulation (SAFEMAP)

For the development of Marine Hazard simulation software, the research is performed in 3 (three) general steps, namely: Literature study, surveys and data collection and modeling and model validation. Literature study covers procedure on marine hazard prevention in Indonesia, global structure of marine hazard simulation software, technological review on marine pollution prevention, international convention on marine hazard prevention, review on accidents evaluation report, risk assessment and risk management, modeling and simulation, software development procedures, etc. Surveys and data collection deals with expected output to shipyard, shipping company as well as classification society, data requirement from shipyard / shipping company / classification society, SRIC data, MarHaz development in Japan and survey on existing simulation related to marine hazard prevention [8-12]. Modeling and model validation would be performed by creating modules for simulation software. Type of modules will be designed by as much as possible taking input from surveys into consideration.

Participants are divided into clusters that play the role as captain, ship owner, Maritime Safety Agency (hereafter MSA), mayor of the city, and so on. In this simulation they must cope with the consequences and challenges of the incidents over a period simulation of a week or more. They have to experience all process from sailing out to the compensation for the environmental damage by using their personal computer (hereafter PC). The cluster tries to solve, analyze and find the solutions of the incident with spill oil, by simulating their position along with their duties and responsibility.

During the participants are coping with the large-scale marine hazards in the imaginary experience, they will be able to configure the process and system of measures as well as enforcement, prevention system and laws. Moreover, they will also be able to determine the required machinery, hardware, logistic system of the prevent material. The participants are also being directed to compare and consider the simulation that they have done with the present prevention system and regulation. The role of the participants is managed as shown in Figure 1.

3.2. LAN design

The email system of the simulation model of the university’s LAN is shown in Figure 2. Every participant has a role and provided with one PC as well as their e-mail address. Usually the participants are divided into 6 (six) groups include one or two advisers. The advisers can read all dispatched and received mail within the group.

![Fig 1. Clustering Participants](image-url)
3.3. Software Development

Basic idea and flow of the simulation is shown as Figure 3. The Marine Hazard simulation developed in this research is configured within 2 (two) general packages of program; program that will be installed on a computer set as a server and the program that will be installed on the computers set as the clients. All participants’ definition and set up are controlled within the server. Server is also dedicated as a device to summarize the simulation data traffic and information. Splash screen of the simulation program is shown in Figure 4.

There are 4 main menus available (see Figure 5), namely: Main Menu, Tutorial Menu, Help Menu and Database Menu. The Main menu is the main facility to carry out simulation process. The Tutorial menu contains an AVI file named SAFEMAPAVI. This file is a movie file, which contains interactive tutorial in how to use the simulation program. The Help menu contains help facility, which is bundled in SAFEMAPHELP file. The last menu, the Database menu, contains the data in regards to cost, resources required in performing the simulation.

From the simulation process involving 6 groups and 21 participants (actors) some facts are obtained. Figure 6 shows number of e-mail circulations among the participants. Considering this, the importance level of each participant can be analyzed. This brings an implication on how important the role of the participant in countermeasure process of the marine incident. Evaluation on the sufficiency of resources required for countermeasure process can also be performed by reviewing the required resources information at the end of the simulation. This will also can be further developed in evaluating the cost-efficiency of the process.

Table 1 shows an example of dependency matrix based on the number of e-mail circulation among the participant of Group 1. As shown, Participant B and D exchange information the most among them. We roughly can presume that dependency of both A and B is higher compare to others and this implies that any justification and decision must be made shorter and prioritized to be able to reduce time for task completion. On the other hand, A share the minimum interaction with others and this implies the role of A may be substituted by other actor, or the involvement of A in the countermeasure process can be ignored.
Table 1. Dependency matrix

<table>
<thead>
<tr>
<th>Group</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>36</td>
<td>24</td>
<td>80</td>
</tr>
<tr>
<td>B</td>
<td>58</td>
<td>219</td>
<td>421</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>43</td>
<td>217</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>80</td>
<td>422</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

Cost requirement each round

Fig. 7 E-mail recapitulation

Cost distribution among the participants can also be reviewed as in Figure 7. As shown, the cost for each participant tends to decrease as simulation is repeated. Considering this, at a number of repetitions, we will end with an optimal procedure in encountering marine hazard by selecting the one having minimum cost. This cost recapitulation is also in concordance with the required resources as well as the time for task completion.

4. TEXT MINING CONCEPTS

4.1. Text Mining

Text mining is a process in obtaining, collecting and analyzing data valid, information, and knowledge from some textual data and then clustering them into pre-defined clusters. Some methods are available in text mining process. Those methods are indexing, special neural network processing, linguistics, ontology, etc.

The text mining computer program used within this simulation takes free structural textual data as the objects. The tool used to compose the code is Text Analyst for Internet Explorer composed by Megaputer Intelligence, Inc. Software. Using this text mining program, some analyses can be performed. Those are words searching and words collecting from a scattered textual data, semantic analysis, words clustering, and ontology building.

The text mining program is composed in a such a way to make it compatible with the internet explorer as the web browser program. This also inline with the code structure of the marine hazard simulation that uses PHP Programming run in Web browsing Internet Explorer.

4.2. Text Mining Algorithm

Sequences of the text mining process is commenced by preprocessing in which textual data is selected (eliminated), supplement words such as a, an, and, other are semantically analyzed and sorted since they will not be taken in the process.

After the completion of the preprocessing, then neural network program will statistically search all important concepts which are words and words combination based on the appearance frequency within the text. The Text Analyst is then counting the number of the appearance of important word within the elements semantic. The program will also count the dependency of word(s). A diagram of concept structure will eventually constructed with their semantic weight as shown in Figure 8. At last, renormalization is the final procedure in which all evaluation on textual data will be summarized.

4.3. Computer Program Architecture

The first Interface of the computer program consists of some facilities in using the program and a link to commence the simulation. This first interface also contains a link to control panel, in which all simulation setting can be done. This process is used to set the participants of the simulation, setting the scenario, database, main particulars and other identification of the ships, and some other setting sequences to enable simulation. Figure 9 shows the first interface of the program:
After the log in process, all participants will have the main menu of the simulation program on the screen as shown in Figure 10. The main menu of program has several button such as main page, Send Message, View Message, Scenario, and Data Analysis.

Database structure of the program consists of a main database as well as a database to record all information obtained during the simulation as shown in Figure 11 and 12.

As shown in Figure 11, the main database is called “simulation admin”. This database consists of data that classified as accident category, simulation guidance, and simulation data. The simulation database itself will collect all data created during the simulation process and classified into general scenario, detailed scenario, report and response as well as the player (participants) of the simulation.

The Tool used for text mining is TextAnalyst for Internet Explorer. This software is executed in interface Microsoft internet explorer. This software contains several main window such as Summary, Semantic Net (SemNet), and Semantic Search (SemSearch) (see Figure 13).

Semantic Net is used is used to view all important concepts within a text document and to show the hierarchical structure of the text document. Within this window, all concepts are arranged from the concept having the highest semantic weight to the lowest. From this window, we also can outlook the relationship between one concept to the other. The weight of each relationship can be quantified using a range of weight from 1 to 100. A weight of 100 means the most important concept within the text document while 1 is the most unimportant concept. Every concept within the Semantic Network can also be connected to the main concepts.

Semantic search is utilized to search concept within a text document. Window of the semantic search consists of several button such as search, clear, and View Pane. By typing a word or a phrase then clicking the search button, Text Analyst will create the semantic structure and display it in the view pane.

Window summary displays the conclusion of the text documents and can be viewed from the view pane.

5. Discussion

From the development of this simulation for marine hazard countermeasure and its simulation process, some important points can be obtained:

1. This simulation is considered to be a very important tool in reducing the cost, resources, and time for performing simulation compared to the physical simulation. From the simulation process we could develop several scenarios and at the end of the simulation a system procedure in encountering the hazard could be developed.

2. This kind of simulation could be further developed as a training tool for the benefit of not only parties involved in...
the marine hazard countermeasure process, but also for public who directly affected by the hazard.

3. **Text Mining** method can be very robust to analyze all simulation data, or data obtained from the simulation process that mainly consists of a textual data. Its coverage could be customized and very depends upon the object to be analyzed. This method can also be used to shorten the time taken to analyzed huge textual data obtained during the simulation process.

6. References


