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Latent-Cause Extraction Model in Maritime Collision Accidents Using Text Analytics on Korean Maritime Accident Verdicts

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Abstract: Maritime collision accidents occur frequently and result in huge damages. Complex collision accidents are especially associated with worse damages. Complex maritime collision accidents involve other types of accidents barring the main accident, such as fire, explosions, capsizes, sinking, and even casualties. When a maritime accident occurs, the maritime accident verdict covers the surveyed facts from the origin of the accident to the consequences. The survey usually reveals the primary cause of the accident; however, complex causes may remain latent. Therefore, this research aims to apply text analytics to maritime verdicts of collision accident cases to identify the latent causes in complex collision accidents. The proposed methods separated the collected corpus into the training dataset and the test dataset. The word propensity database was extracted from the training dataset and applied to sample verdicts of complex maritime collision accidents in the test dataset. The expected results of this research were words that appeared in only complex maritime accidents with a high propensity for additional categories and the relevant context that explains the latent causes that underlie the complexity of the maritime accident. The conclusion suggested that the latent causes derived should be provided to ships to help prevent future complex collision accidents.

Keywords: complex maritime collision accident; latent cause; text analytics; word propensity

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1. Introduction

Collision accidents in a maritime environment primarily occur due to environmental factors, human error, and mechanical failures [1,2]. When an accident occurs, investigations are conducted to prevent re-occurrences because maritime collision accidents usually lead to casualties, environmental damages, and economic damages [3]. In South Korea, the Korea Maritime Safety Tribunal (KMST) dispatches investigators to the scene to conduct a survey and to accurately identify the causes of the accident [4]. Information obtained from the investigation must be contained in the verdict and categorized based on the type of accident. However, when one takes a careful look at the verdicts, some cases are not merely collision accident cases but involve other types of maritime accidents. One collision case resulted in damages only to the ship's hull from a crash, but another case involved fires and explosions, crew deaths, and capsized ships. Nevertheless, both accidents were statistically categorized as "collision" accidents regardless of whether the accident was complex. The complex nature of maritime collision accidents is however apparent because the maritime environment itself is exposed to various hazards, many of which can lead to accidents [5,6], but since complex maritime collision accidents lead to worse consequences than non-complex ones, latent causes have to be identified to prevent future complex maritime collision accidents.

This study uses textual data. Text analytics in other fields of research and industries have usually concentrated on practical purposes [7–9] such as semantic analysis of customer opinions about products, improving product quality and the efficiency of workflows [10,11], or visualizing the interaction and connection between text information [12]. Accordingly, this paper used a large corpus of text data to extract certain underlying characteristics of texts, but unlike traditional text analytics, we extracted the trends in the use of words. Words that appear in a document with a certain purpose tend to reflect the concept conveyed by that document [13,14]. In the case of cultural articles, these conceptual words are already marked as cultural words, including words found in these types of articles and words labeled as "cultural" [15]. In this paper, this characteristic of a text is called "propensity". The word propensity for accident categories can reveal words pointing towards hidden causes in the verdicts. The categories for the "major maritime accidents" designated by KMST are "collision," "fire explosion," "capsizes," "casualty," and "sinking." In this paper, we used five major categories of accidents for the extraction of word propensity and applied the propensity data to verdicts of collision accidents to reveal the latent causes behind complex collision accidents.

Various research studies on the prevention of maritime collision accidents have used different techniques such as HFACS [2], MDTC model [16], and fuzzy cognitive maps [17], for example. The results of these research studies included human factors, environmental factors, collision situations, and contributors of collisions. Other research studies also focused on an analysis of maritime collision accident causes and derived specific results that impacted the collision of ships. Still, the prevention of collision accidents is challenging because of the uncertainty about the causes of an accident that are uncovered and the possible hidden causes that are not explicitly highlighted [18]. However, it may be possible to prevent complex collision accidents. Since verdicts are written by different investigators who have various analytical perspectives and who follow the requirements of various investigation approaches [19], it is very difficult to perform latent-cause examination simply by reading the verdict. Therefore, we tried to use a data-driven approach using text analytics to reveal latent-cause words and their relevant contexts in verdicts about complex maritime collision accidents. If the relevant contexts of latent causes are found worthy, the results of our proposed method can be used to prevent future maritime collision accidents and potentially more damage.

2. Materials and Methods

The proposed method includes an experimental design starting from data preprocessing to latent-cause word extraction. We extracted the word propensity from a larger corpus and applied it to sample verdicts. Figure 1 describes the steps in the workflow of our research method.

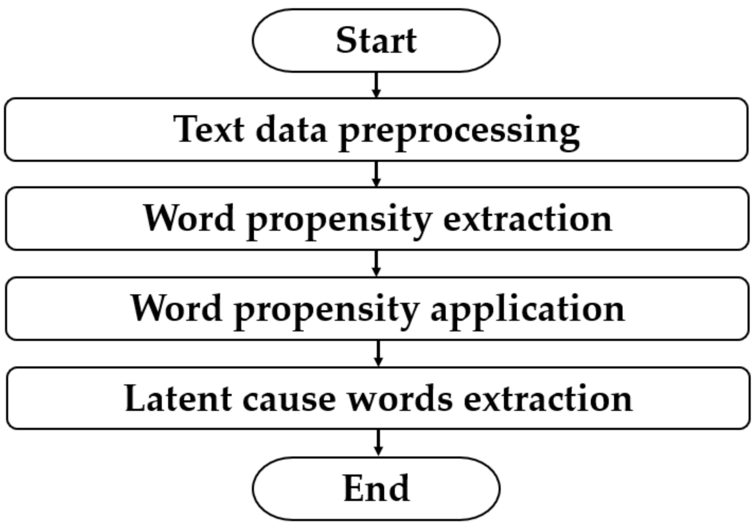

Figure 1. Workflow of our proposed method.

2.1. Text Data Preprocessing

2.1.1. Raw Data of Maritime Accident Verdicts

The first step, "Text data preprocessing," starts from data collection. The data in this research were collected from the KMST's open-source verdicts from accident cases gathered over a period of eight years, from 2014 to 2021.

The verdicts gathered included 748 cases of maritime accidents under the five major categories designated by KMST. We separated the collected verdicts into 608 cases in the training dataset and 140 cases in the test dataset. The training dataset consists of all categories of accidents and is used for the extraction of word propensity. In contrast, the test dataset consisted only of collision cases to apply the word propensity data extracted from the training dataset. A sample maritime verdict is shown in Figure 2.

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【판시사항】

[1]이 충돌사건은 대영호가 연료공급 계통 스트레이너(Strainer) 정비작업을 소홀히 하여 항내에서 출항 중, 연료유 스트레이너 선택 레버가 적정위치에서 벗어남으로써 주기관에 연료유 공급이 차단되어 주기관이 갑자기 정지되면서 발생한 것이다.

[2]선박의 주기관은 가장 중요한 기기로서 주기관 운용에 필요한 정비작업을 수행할 때에는 반드시 기관장 또는 실무책임자인 1등기관사의 직접적인 관리·감독하에 수행되어져야 한다.

[3]선박의 정비예정작업 사항에 대해서는 작업 수행 전 반드시 기관장 또는 실무책임자에 의해 작업수행시의 안전이나 주의사항에 대한 교육(TOOL BOX MEETING)을 실시해야 한다.

【해양사고관련자】

A(A호 일등기관사, 2급기관사)

B(A호 기관장, 4급기관사)

【주문】

이 충돌사건은 대영호가 연료공급 계통 스트레이너(Strainer) 정비작업을 소홀히 하여 항내에서 출항 중, 연료유 스트레이너 선택 레버가 적정위치에서 벗어남으로써 주기관에 연료유 공급이 차단되어 주기관이 갑자기 정지되면서 발생한 것이다.

해양사고관련자 A의 2급기관사 업무를 1개월 정지한다.

해양사고관련자 B를 견책한다.

Figure 2. Sample maritime accident verdict.

The sample in Figure 2 is the first part of a full verdict. A full verdict includes the sections "Adjudication", "Holding", "Persons involved in the maritime accident", "Judgement", and "Reasoning" and includes descriptive drawings. In Appendix A, we provide a translated version of a sample verdict to provide a better understanding of the verdict structure, with private information anonymized.

2.1.2. Preprocessing Conditions

As in Table 1, we sorted the training data into five major accident categories: "casualty," "sinking," "capsizes," "collision," and "fire explosion." The verdicts were written using Korean words, but the language used does not affect the analysis using the proposed methods. The primary preprocessing steps were "punctuation removal," "non-Korean words removal," and "tokenization." Figure 3 describes the precise preprocessing procedure, including the translated text.

Table 1. Collected verdict data.

Category	Number of Verdicts	Training Dataset	Test Dataset
Casualty	67	67	-
Capsizes	34	34	-
Collision	550	410	140
Sinking	36	36	-
Fire explosion	61	61	-

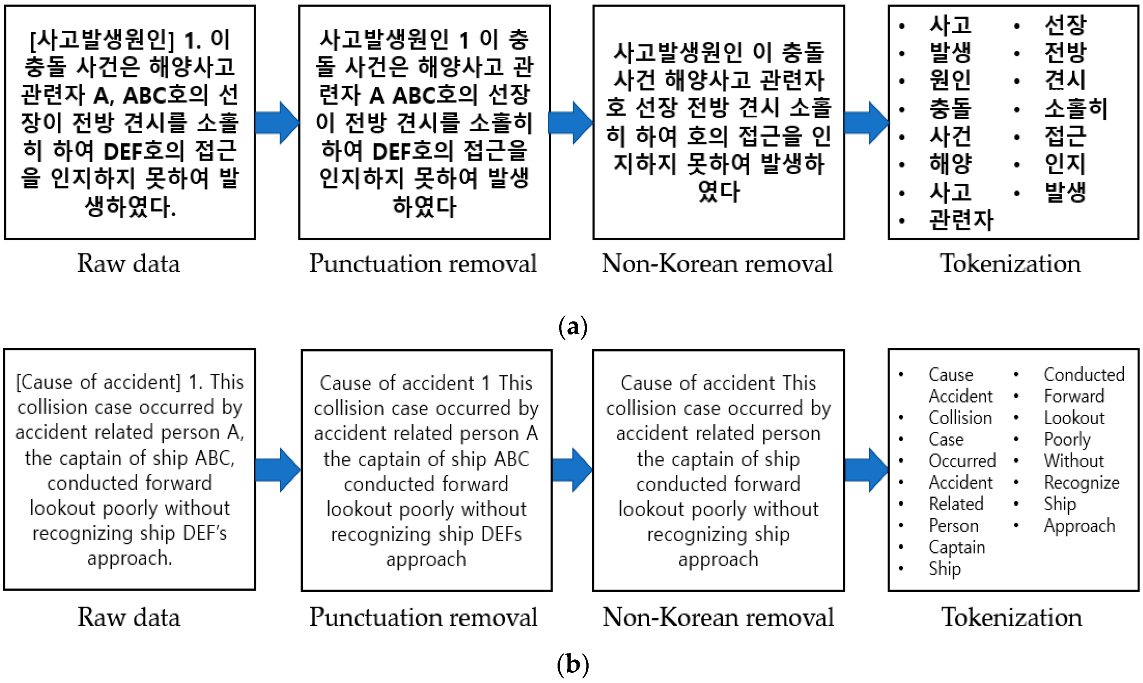

Figure 3. Precise text data-preprocessing procedure: (**a**) Korean text; (**b**) translated text.

2.2. Word Propensity Explanation and Examples

2.2.1. Word Appearance Frequency Extraction

The preprocessed word list was prepared in the previous section. Here, we extracted the word appearance frequencies for each category. Each word had different frequencies for each category, showing the propensity for the particular categories. An example of word appearance frequencies is shown in Table 2. However, an additional process of normalization is conducted on the frequency values to obtain the least objectivity of word propensity of each word.

Table 2. Example of word appearance frequencies.

Words	Casualty	Sinking	Capsizes	Collision	Fire
Word a	5	12	2	1	98
Word b	3	120	17	2	9
Word c	1	1	67	0	0
Word d	0	21	10	250	7
Word e	80	2	4	10	3

2.2.2. Word Propensity Extraction

The example word list and counts in Table 2 show the frequency of words used for different categories. Here, we normalized the extracted frequency data, considering the different number of cases and the number of words in each verdict to obtain the minimum objectivity of a word's appearance in the text. If the normalization step were to be skipped, the words in lengthy verdicts and dominant cases would become more frequent. The normalization process is described in following equation.

$$\text{Normfreq} = \text{freq} \times \frac{\text{vLCM}}{\text{N}} \times \frac{\text{cLCM}}{\text{C}} \times \text{cfreq}$$

where "freq" is the original frequency of the word in the verdict of a category, "Normfreq" is the normalized frequency, "N" is the number of words in the verdict, "vLCM" is the least common multiple for the number of words in verdicts of the category, "C" is the number of categories in the corpus, "cLCM" is the least common multiple for the number of categories in the corpus, and "cfreq" is the total frequency of the word in the corpus. The normalized frequency of a word was considered to obtain the minimum objectivity of each word. Thus, after the normalization, the values in the table were converted into percentage values to equalize the sum of each word's normalized frequency over a hundred. The percentage data for word appearance for each category presented here represent the word propensity, as arranged in Table 3, for example.

Table 3. Example of word propensity.

Words	Casualty	Sinking	Capsizes	Collision	Fire
Word a	4.2%	12.2%	1.7%	0.8%	81.1%
Word b	2.0%	79.5%	11.3%	1.3%	6.0%
Word c	7.4%	1.4%	91.1%	0.0%	0.0%
Word d	0.0%	10.3%	8.5%	73.8%	7.4%
Word e	69.8%	5.0%	7.0%	10.1%	6.0%

Table 3 shows the different appearance characteristics of words for each category. In the case of "Word a," the word propensity is as high as 81.1% for "fire explosion" cases, meaning "Word a" is likely to appear in "fire explosion" accidents. Similarly, each word shows a particular propensity, such as "Word b" for "sinking" cases, "Word c" for "capsizal" cases, "Word d" for "collision" cases, and "Word e" for "casualty" cases. These appearance characteristics of words are the central concept behind word propensity in the proposed method, and we applied the extracted word propensity from the training dataset to verdicts in the test dataset.

2.3. Word Propensity Application

The application of the extracted word propensity was applied to the sample verdicts from the test dataset. As explained previously, the sample verdicts consisted of 140 cases of "collision" accidents. Here, we used 30 cases of "ordinary collisions", which did not involve any other type of accident, only a collision, and 30 cases of "complex collisions", which involved other types of accident. The two groups were selected by reading all verdicts in the test dataset. Since the original data are text data, it was possible to examine whether any of the five "major accidents" involved other types of accidents. Then, we applied the word propensity data to all selected verdicts and derived verdict propensities. Verdict propensity describes a word's accumulated propensity from the first to the last word throughout the verdict. As a result, the verdict propensity of the sample verdicts showed propensities for the particular type of accident. Figure 4 describes an example of verdict propensity.

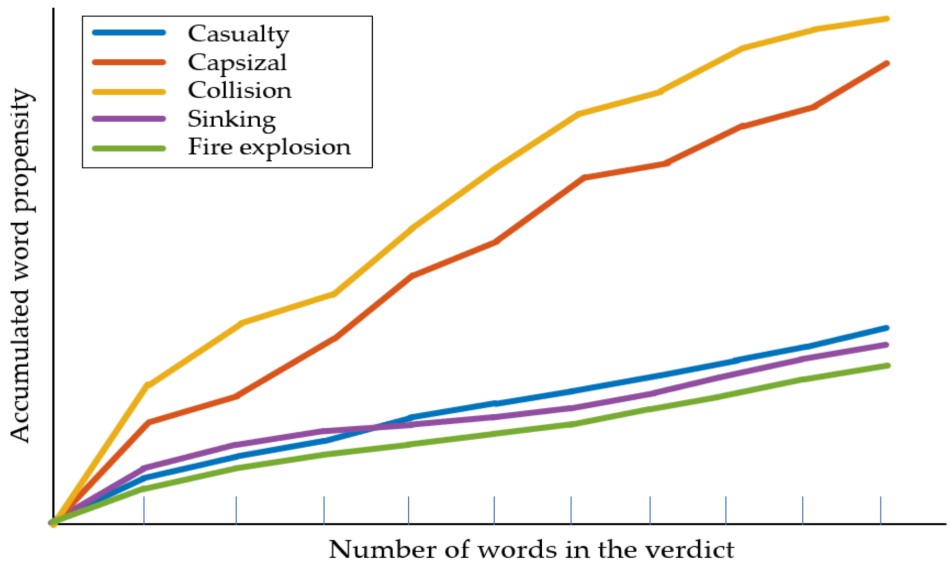

Figure 4. Example of verdict propensity.

Figure 4 presents a stair plot for verdict propensity when the total number of words used in the verdict was only ten. The word propensity was accumulated using corresponding words in the verdict, indicating the overall propensity for one of the five major maritime accident categories. The propensity for collision would be the highest because the case involves collision accidents, so the category of the second-highest propensity or outstanding propensity would be the target category for the extraction of latent-cause words.

2.4. Latent-Cause Word Appearances in Complex Maritime Accidents

Latent-cause words were extracted by finding the words that appeared only in "complex collision" cases and not in the "ordinary collision" cases. Here, we compared the sample verdicts in the two groups, excluded the words that appeared in both groups, and extracted those that appeared with high propensity for particular categories in the "complex collision" cases. As the proposed methods aim to find latent-cause words, the words that appeared in the sample "complexed collision" verdicts were extracted for the top five words that showed the highest propensity for particular additional accident categories. The reason we selected only the top five words is due to the difference in the number of words in the results among the categories. In other words, some categories of accidents had 20 possible latent-cause words while others had only 6 latent-cause words. Therefore, we settled on the criteria for number of words being the top five words.

3. Results

The results of the proposed methods derived from the word propensity extraction for latent-cause words and contexts are presented in this section. We extracted the word propensities from the training dataset, arranged them in a table, and visualized the verdict propensity data. The latent causes for each additional category were examined using related contexts for each word.

3.1. Word Propensity Derived from the Training Dataset

The proposed method took the words from the training dataset as the source of word propensity extraction. The total number of words extracted from the training dataset was 1,067,043. Some of the words only formed parts of expressions, and others were particular ship-operation-related words. After the preprocessing, the number of tokenized words listed was 9442, and we extracted the word frequencies. The frequency values were normalized to remove the difference in total words for the verdicts and the difference in the number of cases for each category. Then, we converted the normalized frequency values of each word into percentage values as propensity values. The list of (translated) words and propensities is shown in Table 4.

Table 4. Extracted word propensity data.

Word (Translated)	Casualty	Capsizes	Collision	Sinking	Fire and Explosion
(1) Hitting	95.39%	0.00%	0.48%	0.00%	4.13%
(2) Hole	9.89%	0.00%	2.29%	39.87%	47.96%
(3) Twisted	91.22%	0.00%	0.00%	8.78%	0.00%
(4) Refrigerator	0.00%	12.05%	2.40%	2.28%	83.28%
(5) Wave	24.61%	35.49%	1.36%	37.20%	1.35%
(6) Flipped	4.62%	92.61%	2.77%	0.00%	0.00%
(7) Material	12.38%	1.02%	0.93%	0.39%	85.28%
...	...	...	...	...	...
(9436) Lubrication	0.00%	7.37%	0.52%	12.43%	79.67%
(9437) Locked	5.88%	0.00%	0.00%	51.07%	43.05%
(9438) Equipment	18.89%	24.97%	15.34%	15.55%	25.24%
(9439) Loaded	6.93%	59.67%	3.58%	23.72%	6.10%
(9440) Light bulb	0.00%	0.00%	1.89%	20.86%	77.25%
(9441) Drowsiness	0.00%	0.00%	58.18%	0.00%	41.82%
(9442) Fatigue	26.68%	2.87%	27.59%	30.05%	12.81%

Since some words have a particular propensity for a certain category and others have propensities for as many as five categories, we measured the standard deviation of each word propensity to determine the differences among the words. As a result of an examination, a lower standard deviation for a word propensity turned out to mean that the word had appeared relatively frequently throughout the five major categories and a higher standard deviation meant that the appearance of a word was biased toward a certain category. The standard deviations of the word propensities are shown in Figure 5.

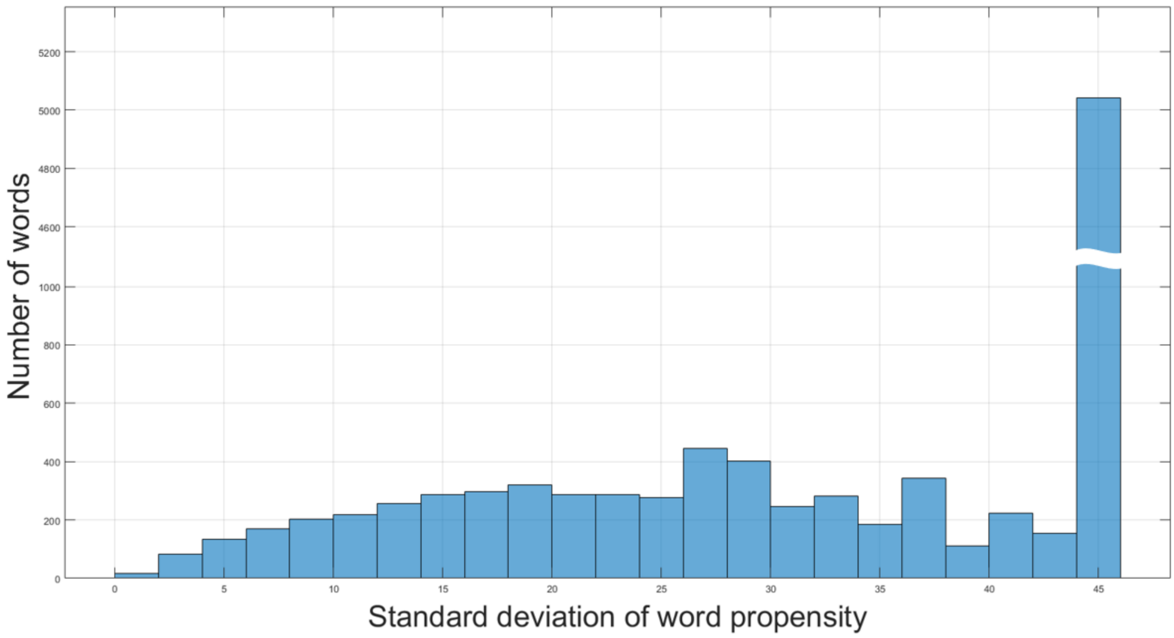

Figure 5. Distribution of the standard deviation for each word propensity value.

Figure 5 shows the differences among the word propensities. Whether common or biased, all of the word propensity data were used for the verdict propensity extraction.

3.2. Application of Word Propensity to the Separated Groups of Verdicts

Here, we applied the word propensity to two different groups of collision-accident verdicts from the test dataset. As a result of the application, the "ordinary collision" group and "complex collision" group showed noticeable differences. The samples of verdict propensity for the two groups are presented in Figures 6 and 7.

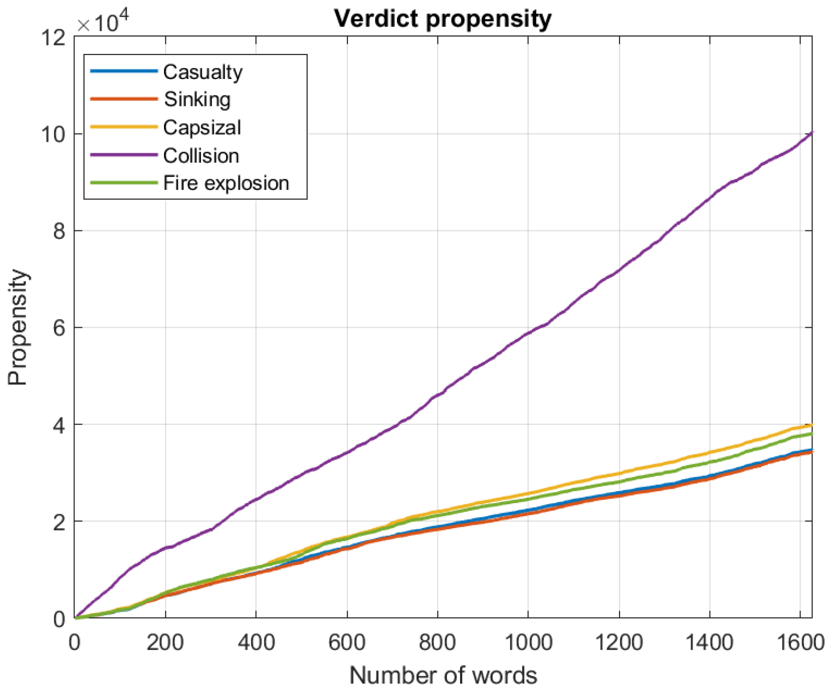

Figure 6. Verdict propensity of "ordinary collision" accident cases.

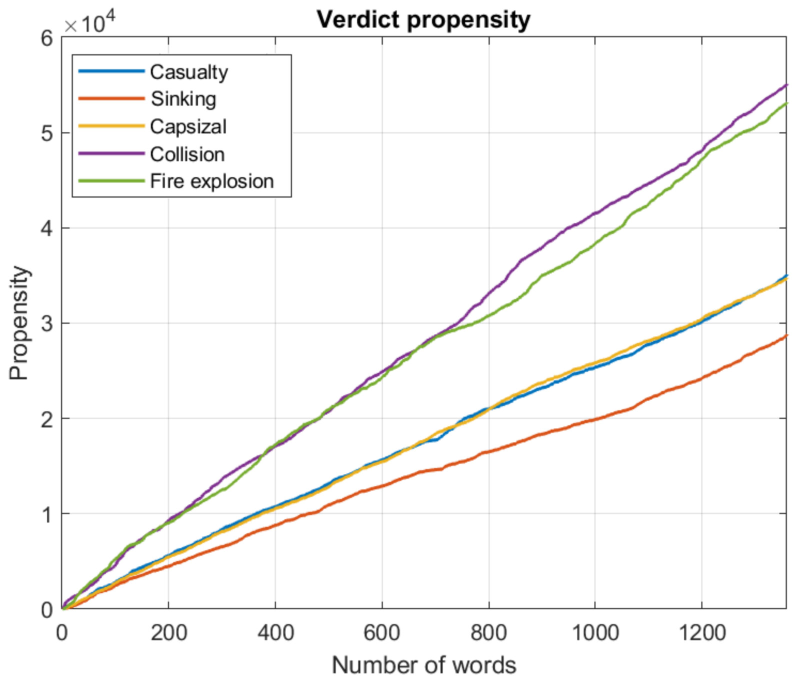

Figure 7. Verdict propensity of "complex collision" accident cases.

The verdict propensity in Figure 6 is from the "ordinary collision" cases, in which categories other than "collision" are bunched close together without showing much difference. In contrast, in Figure 7, in the "complex collision" cases, the propensity for certain categories was located higher and far from other categories.

3.3. Arrangement of Latent Cause Words in Complex Maritime Accidents

The verdict propensity above could provide an overview of the verdict propensity but not the specific reason for obtaining those results. Here, we extracted the particular words that appeared for certain categories in "complex collision" cases. As mentioned in the Materials and Methods section, the words that appeared in both groups were excluded in the extraction of latent words. Words that had appeared in a particular category were examined separately and sorted along with their propensity. The results of the latent-cause words are listed in Tables 5–8 for the categories "casualty," "capsizes," "sinking," and "fire explosion" with the top five words listed in the order of their most common appearance.

Table 5. Latent-cause words in complex collision accidents in the category of "casualty."

Word (Translated)	Casualty	Capsizes	Collision	Sinking	Fire and Explosion
(1) Bounced	98.19%	0.00%	1.81%	0.00%	0.00%
(2) Symptom	94.83%	0.00%	5.17%	0.00%	0.00%
(3) Drunk	71.59%	0.00%	28.41%	0.00%	0.00%
(4) Unlicensed	68.68%	0.00%	21.28%	5.33%	4.71%
(5) Wearing	65.83%	18.04%	1.03%	8.08%	7.01%

Table 6. Latent-cause words in complex collision accidents in the category of "capsizes."

Word (Translated)	Casualty	Capsizes	Collision	Sinking	Fire and Explosion
(1) Lower	0.00%	97.31%	2.69%	0.00%	0.00%
(2) Piece	9.95%	73.54%	2.85%	0.00%	13.66%
(3) Asked	26.60%	73.40%	0.00%	0.00%	0.00%
(4) Reject	6.42%	42.18%	6.25%	10.46%	34.68%
(5) Trim	0.00%	40.53%	1.39%	58.08%	0.00%

Table 7. Latent-cause words in complex collision accidents in the category of "sinking."

Word (Translated)	Casualty	Capsizes	Collision	Sinking	Fire and Explosion
(1) Updated	0.00%	0.00%	7.00%	93.00%	0.00%
(2) Interfered	0.00%	0.00%	11.50%	88.50%	0.00%
(3) Too short	0.00%	0.00%	20.17%	45.94%	33.89%
(4) Systemical	25.48%	0.00%	18.74%	43.60%	12.19%
(5) Ahead	0.00%	0.00%	65.57%	30.57%	3.87%

Table 8. Latent-cause words in complex collision accidents in the category of "fire explosion."

Word (Translated)	Casualty	Capsizes	Collision	Sinking	Fire and Explosion
(1) Short	0.00%	0.00%	0.24%	0.45%	99.31%
(2) Forgot	0.00%	0.00%	21.55%	0.00%	78.45%
(3) List	0.00%	0.00%	37.31%	0.00%	62.69%
(4) Essential	0.00%	0.00%	35.01%	23.46%	41.53%
(5) Checked	0.00%	0.00%	7.54%	57.26%	35.20%

For some of the words in Tables 5–8, it was possible to interpret the reason for their appearance in the verdict, but others were rather awkward to interpret without the context of the original verdicts. The specific interpretations of latent-cause words are discussed in the Discussion section.

4. Discussion

The results of the word propensity derived from our proposed method is presented in Table 4, and visualizations of the verdict propensities are shown in Figures 6 and 7. The latent-cause words are arranged along with the categories in Tables 5–8 as the top five categories with frequent appearances. The purpose of this research was to find the latent-cause words that transformed an "ordinary collision" accident into a "complex collision" accident, so our discussion of the result is focused on the interpretation of the frequency of word appearance within the original context in "complex collision" accident verdicts.

4.1. Application of Word Propensity to the Separated Groups of Verdicts

Figures 6 and 7show the differences in verdict propensities between "ordinary collision" and "complex collision" cases. The verdict propensity, which is an accumulation of the word propensity and the words themselves, increases differently and ends at specific values for each category. The reason for the differences in the phases of the graph could be understood by extracting the words and finding their contexts. Our interpretation of these latent words in Tables 5–8 represents an important result of this paper. If the raw data size was much greater, the word propensity data could have been much more significant. Nevertheless, even with the relatively small size of the raw data, the word propensities and verdict propensities were used to derive the latent-cause words and contexts from original verdicts of "complex collision" cases.

4.2. Contexts of Latent Cause Words in Complex Maritime Accidents

The words presented in Tables 5–8 are not unique words but rather common words. However, their contexts suggest that their use was quite reasonable, considering the situation of a collision. "Casualty" words included "bounced," "symptom," "drunk," "unlicensed," and "wearing." The first word, "bounced," appeared in the following context: "the crew bounced off the control console and were seriously harmed." The second word, "symptom," appeared in the following context: "the crew felt the symptoms of a propeller malfunction but ignored them." The third word, "drunk," appeared in the following context: "the captain (or officer) had drunk the liquor or liquefied medicine." The fourth word, "unlicensed," appeared in the following context: "the captain handed over control of the ship to an unlicensed person." The last word, "wearing," appeared in the following context: "none of the crew members working on the deck were wearing life jackets." When we examine the contexts in the original text, the meanings of words then become understandable. However, some of the results were hard to identify as a latent cause but were rather obvious in the collision accident case. The results of the extraction (the words and their contexts) for the other categories are arranged in Table 9.

The contexts given in Table 9 show that the condition of the ship was abnormal already before the ship collided. After examining the contexts of the latent-cause words, we found that additional accidents within the "complex collision" accident could have been prevented if simple regulations had been followed or minor maintenance matters had been properly cared for. In the "annual statistic report" for 2020 surveyed by the "Korea Maritime Safety Tribunal" [20], the specific causes of collision accidents included "lack of preparation", "lack of hydrographic survey", "lack of positioning of ship", "poor course keeping", "poor watch keeping", "lack of machinery maintenance", and others. Appropriately, from the results of the context provided above, even from a few sample verdicts, we were able to find the corresponding causes of accidents, e.g., "ignorance of abnormal symptoms from equipment", "outdated nautical chart", and "unchecked condition of equipment". In other words, the proposed method derived relevant causes of accidents and their contents from a "complex collision". Therefore, considering the purpose of this research, which was to analyze the latent causes of complex collision accidents, the proposed methods proved that the latent causes of an accident can be derived in detail and possibly provided to ships to prevent further "complex collision" accidents.

Table 9. Context of the extracted words from the original verdicts.

Category	Context in the Verdict (Translated)
(1) Casualty	"The crew bounced off the control console and were seriously harmed." "The crew felt the symptoms of a propeller malfunction but ignored them." "The captain or officer had drunk the liquor or liquefied medicine." "The captain handed over control of the ship to an unlicensed person." "None of the crew members working on the deck were wearing life jackets."
(2) Capsizes	"The height of the ship's bridge was lower than that of the other ship." "In front of the bridge, a large piece of the ship structure was loaded." "The captain asked the officer if anything had happened during the duty." "The crew members did not reject the unwarranted order of the captain." "The ship always has to keep the trim within 10 degrees for safety reasons."
(3) Sinking	"The nautical chart of the ship was not updated." "The captain's decision should not have been interfered with." "The distance to the pier was too short when the engine stopped." "The owner of the ships did not provide systemic safety management." "The ship was sailing by taking the wind from ahead of the ship."
(4) Fire and explosion	"The captain found out that fire started from a short circuit in the cable." "The crew forgot to turn on the auxiliary blower for the main engine." "Crew members were not using a checklist of equipment before sailing." "The conditions of essential equipment should be maintained." "The main engine and equipment were not tested and checked."

5. Conclusions

This research applied text analytics to maritime verdicts. Maritime verdicts constitute delicate investigations, and almost everything related to an accident is revealed in its verdict. Therefore, this research focused on finding latent causes in "ordinary" collision accidents that make them "complex" collision accidents. Maybe the results of the research were simply the coincidental outcome of a certain usage of words, but the results of the proposed method showed detailed additional causes of these accidents that matched the annual report of the "Korea Maritime Safety Tribunal". Even with the latent causes of complex collision accidents gathered from advanced results being provided to ships, it may be hard to prevent maritime collision accidents from occurring, but at least possible aggravation of accidents can be prevented. Furthermore, text analytics using the extraction and application of word propensities is a novel concept in text analytics. In the future, we will collect a larger corpus of text data and use advanced methods of text analytics to address safety in maritime industries.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

This section describes the sample verdict presented in Figure 2 for a better understanding of the contents of the maritime accident verdict provided (in a translated version).

[Adjudication] Busan Maritime Safety Tribunal No. 2019-052 (collision accident between four ships, including oil tanker "Ship A" and plying boat "Ship E").

[Holding]

[1]. This collision accident was caused by "Ship A" neglecting maintenance of their strainer in the fuel supply system; during departure from the port, the fuel oil strainer selection lever deviated from the correct position, the fuel oil supply to the main engine was blocked, and the main engine suddenly stopped.

[2]. The main engine of a ship is the most important apparatus, and when performing any maintenance work necessary for main engine operation, it must be performed under direct control and supervision of the chief engineer or the first engineer, who is the person in charge.

[3]. For scheduled maintenance work on a ship, before performing the work, education (a ToolBox Meeting) on safety and the precautions that should be taken while performing the work must be conducted by the chief engineer or the person in charge.

[Persons involved in the maritime accident]

A (First Engineer of "Ship A", Second Engineer)
B (Chief Engineer of "Ship A", Fourth Engineer)

[Judgement]

This collision accident was caused by "Ship A" neglecting maintenance of their strainer in the fuel supply system; during departure from the port, the fuel oil strainer selection lever deviated from the correct position, the fuel oil supply to the main engine was blocked, and the main engine suddenly stopped. The maritime accident involved person A, the second engineer, is thus suspended from duties for 1 month. Person B involved in the maritime accident is reprimanded.

[Reasoning]

1. Facts

Table A1. Information of ships involved in the accident.

Ship Name	"Ship A"		"Ship B"
Port of Registry	Ulsan City		Ulsan City
Ship Owner	C		D Marine Co., Ltd.
Gross Tonnage	626 Tons		13.1 tons
Engine type/output	1 diesel engine/735 kw		1 diesel engine
Marine accident involved person	A	B	-
Official title	First engineer	Chief engineer	-
Type of license	Second engineer (**-**-**-****)	Fourth engineer (**-**-**-****)	-
Ship Name	"Ship C"	"Ship D"	"Ship E"
Port of Registry	Ulsan City	Ulsan City	Ulsan City
Ship Owner	D Marine Co., Ltd.	D Marine Co., Ltd.	D Marine Co., Ltd.
Gross Tonnage	10 Tons	11 Tons	24 Tons
Engine type/output	1 diesel engine	1 diesel engine	1 diesel engine
Marine accident involved person	-	-	-
Official title	-	-	-
Type of license	-	-	-
Accident occurred date	around 21:18, 7 February 2019		
Location of the accident	35°30′05″ North latitude, 129°22′27″ East longitude (on the sea in front of plying boat moorings in Jangsaengpo Port, Ulsan City)		

A. Specifications of ships involved

(1) "Ship A" specifications, etc.

"Ship A" was built and launched at the Kyoei Shipyard in Hiroshima, Japan on July 1, 1998, with a gross tonnage of 626 tons (length 56.37 × width 11.30 × depth 5.30 m) and equipped with one diesel engine of 735 kw, registered in Ulsan Metropolitan City as a petroleum product carrier made of steel. It had undergone regular inspection by the Korea Register of Shipping and held a valid Ship Inspection Certificate until 27 April 2019. This ship was a stern bridge-type ship, and from the bow, the ship included the following: a fore peak tank, a No. 1 ballast tank, No. 1 cargo holds (left and right), No. 2 cargo holds (left and right), No. 3 cargo holds (left and right), an engine room, a cabin area, and an aft peak tank (see Figure A1).

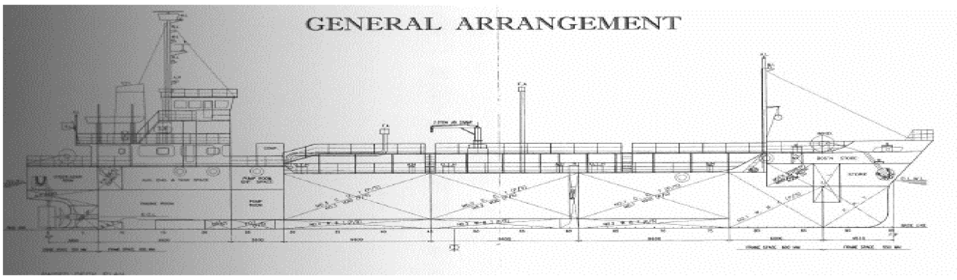


Figure A1. Drawing of the general layout of "Ship A".

This ship mainly loaded oils in bunker A and bunker C from the Jangsaengpo Port, Ulsan City, ported and unloaded at SK oil storage stations located at Yeongdo in Busan City, Jeju City, and Masan City in Gyeong-sang-nam-do. In this ship, a total of nine crew members including a captain were on board, and the crew consisted of five officers and four crew members. The five officers consisted of the captain, two navigators, one chief engineer, and one first engineer, and the crew members consisted of two bosuns, one able-bodied seaman, and one No. 1 oiler.

(2) Specifications for the four ships including "Ship B"

"Ship B" was a plying boat made of reinforced plastic with a gross tonnage of 13 tons (length 15.12 × width 3.90 × depth 1.40 m) and equipped with one diesel engine, built and launched on 1 November 1996 at Changnam FRP Shipyard at Namhae-gun in Gyeongsangnam-do, and registered in Ulsan-City.

"Ship C" was a plying boat made of reinforced plastic with a gross tonnage of 10 tons (length 13.62 × width 3.49 × depth 1.44 m) and equipped with one diesel engine, built and launched on 8 March 2012 at Sehwa FRP Shipyard in Sacheon-City, Gyeongsangnam-do, and registered in Ulsan-City.

"Ship D" was a plying boat made of reinforced plastic with a gross tonnage of 11 tons (length 14.16 × width 3.40 × depth 1.28 m) and equipped with one diesel engine, built and launched on 11 September 2007 at Yongwon Powerboat in Changwon-City, Gyeongsangnam-do, and registered in Ulsan-City.

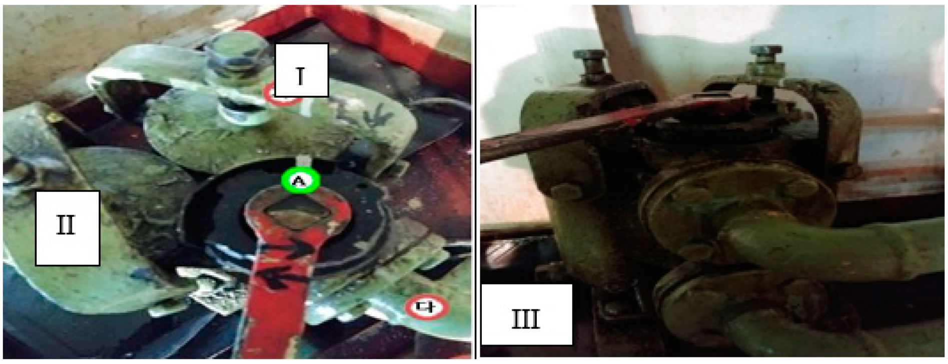
"Ship E" was a plying boat made of reinforced plastic with a gross tonnage of 24 tons (length 19.66 × width 4.00 × depth 2.20 m) and equipped with one diesel engine, built and launched on 31 August 2018 at Buyong Seatech at Saha-Ku, Busan-City, and registered in Ulsan-City.

B. Progress of facts

While "Ship A" was moored in the sea in front of Jangsaengpo Elementary School opposite the SK 2-4 pier in Ulsan Port, the duties of the workers on watch in the engine room of the ship on 6 February 2019, which was the day before the accident, was performed by the first engineer, A (hereinafter referred to as 'First Engineer A'), from 03:10 to 07:10;

by the chief engineer, B (hereafter referred to as 'Chief Engineer B'), from 07:10 to 11:10; and by the No. 1 oiler, E, from 11:10 to 15:10. Usually, this ship writes down the items to be checked during scheduled maintenance work of the engine room on a memo paper, hangs it on the wall of the engine room, and performs the maintenance work according to the schedule. When the maintenance work is completed, the completion of the maintenance work is indicated by two lines drawn on the memo paper, and the first engineer records the items completed during the work in the engine room log.

At that time, according to the work items written in the work log by the first engineer as described above, at around 14:00 to 15:00, 6 February 2019 in the engine room, the No. 1 oiler disassembled and cleaned the primary and secondary fuel oil strainers installed in the two middle locations of the fuel oil (Bunker A oil) supply pipe from the fuel oil service tank to the main engine. When the No. 1 oiler finished the cleaning of the primary fuel oil strainer and was assembling the last one of the two strainers, which were in downstairs, as shown in Scheme A1, First Engineer A arrived at the engine room. Hereupon, First Engineer A illuminated the searchlight so that the No. 1 oiler could finish their work smoothly, and witnessed the work being completed.



Scheme A1. Secondary strainer for fuel oil in the engine room of "Ship A".

When Chief Engineer B went to the engine room in the evening after cleaning the fuel oil strainer finished on 6 February 2019 (the day before the accident), he recognized the two lines drawn in the written work log that the fuel oil strainer cleaning work was completed by crew members, but he did not take any special measures to conduct an inspection.

[1] The fuel oil strainer had a total two strainers on the left and right (refer to Scheme A1). One strainer could be selected and used by pulling on the lever (A in Scheme A1); when this lever was in the neutral (middle) position, it was in the closed state and the fuel oil supply to the main engine was blocked. Additionally, when it was in the middle position, not in the intermediate position or in the strainer position, the main engine could not be normally operated due to a lack of fuel oil supply.

The ship unberthed from the sea in front of the Jangsaengpo Elementary School around 14:45 on the 7th of the same month, the day of the accident; berthed 10 min later at 14:55 at the opposite SK 2-4 pier; and after, loaded 1070 tons of bunker C oil and 10 tons of bunker A oil, which amounted to a total of 1,080 tons of oils from 16:35 to 21:10. The ship departed the SK 2-4 pier on the same day at 21:10. At that time, Captain F, the second officer, and Chief Engineer B were in the wheel house. The captain was in charge of overall duties; the second officer was in charge of steering; and the chief engineer was in charge of the telegraph, which is the main engine bridge remote control system. The first engineer was in the engine room, and the rest of the crew members were deployed to the bow and stern, respectively.

After unberthing from the pier, the ship raised the main engine successively to dead slow ahead (RPM 230), slow ahead (RPM 250), and half ahead (RPM 290). Approximately 3 min after the ship advanced half speed of the main engine, around 21:16 on the same day, when the ship passed in front of the Jangsaengpo Port Wireless Pier in the state at approximately 78° of course and approximately 6.3 knots, the RPM suddenly dropped and the main engine stopped. When the RPM dropped, Chief Engineer B reported to Captain F the fact that the main engine stopped and went down to the engine room. Captain F took over steering in place of the second officer to starboard and, after, instructed the first officer to anchor the ship. The anchor length was fixed at approximately 20 m because the distance from the pier was short, but 2 min after the main engine stopped, on 7 February 2019, around 21:18, by an ahead rudder force, it collided with four ships, including plying boat "Ship E", collectively moored at the plying boat moorings (refer to Figure A2).

First Engineer A looked everywhere to find the problem after the main engine stopped, and the chief engineer, who was in the wheel house at departure time, and the No. 1 oiler, who was at the stern, came to the engine room and said, "The ship collided". The chief engineer and the No. 1 oiler adjusted the lever [1] of the secondary fuel oil strainer that had been cleaned the day before the accident. After that, when the chief engineer operated the main engine, the main engine operated normally. After that, the ship moored safely to a location where the coastal ships at the Jangsaengpo Port were anchored collectively at 21:50 on the same day.

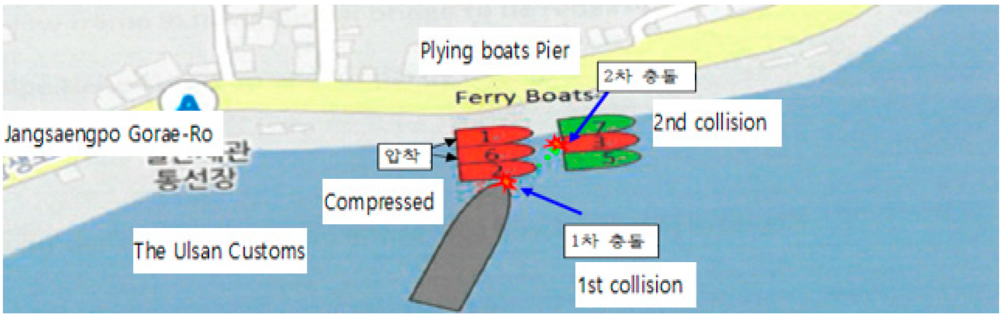


Figure A2. Diagram of the collision situation.

After that, on the 8th of the same month, the day after the collision accident, an Inspector of the Korea Register of Shipping and the CEO of the SMS, a main engine repair specialization company located in Busan, boarded the ship, and they confirmed that "At the time of the accident, the fuel oil secondary strainer lever of this ship was not in the correct position and the fuel oil was not supplied to the main engine, so the main engine suddenly stopped".

The four other ships, including "Ship E", were ships belonging to D Marine and all were registered at Ulsan Port, and their status at that time were as follows: "Ship E" (total tonnage 24 tons, loaded the fuel diesel oil approximately 5000 L), "Ship B" (total tonnage 13 tons, loaded the fuel diesel oil of 800 L), "Ship C" (total tonnage 10 tons, loaded the fuel diesel oil of 500 L), and "Ship D" (total tonnage 11 tons, loaded the fuel diesel oil of 800 L), etc. The four plying boats including "Ship E" were mainly embarking and disembarking crew members while going back and forth between the ships in the Ulsan Port and moorings of the plying boats in a smooth water area. When they had no work, they stayed at the moorings in Jangsaengpo Port. The accident occurred on 7 February 2019, while the four plying boats, including "Ship E", were moored at the plying boat moorings in Jangsaengpo Port after completing their plying boat work. The Daeyeong-Ho, which was departing from Jangsaengpo Port, directly collided first with plying boat "Ship B", which was mooring on the port side of the port; after that, "Ship B" impacted "Ship D" and the next ship, "Ship E", which were moored on the port side, and at the same time, made contact with the stern of "Ship C" ahead (refer to Figure A2).

By this collision accident, the Daeyeong-Ho damaged the paint on its bow; "Ship D" was a total loss after sinking; "Ship B" was damaged on the starboard stern; "Ship E" was damaged on the starboard hull; "Ship C" was damaged of the hull, bent at the starboard stern; and approximately 22 L of diesel and waste oil loaded on "Ship B" spilled into the sea.

2. Causes

This collision accident case falls under Article 2, Item 1 (b), (d), and (e) of the "Act on Investigation and Judgment of Maritime Accidents".

A. Consideration of the Causes

(1) Application of navigation.

This collision accident was an accident that occurred at a night with good visibility between "Ship A", which was departing from the pier when the main engine suddenly stopped, and "Ship B" and the other ships, which were mooring at the plying boat moorings, and it was due to the "Responsibilities of Crew members".

(2) Reason for the main engine of "Ship A" suddenly stopping

During "Ship A"'s departure from the port, after the main engine suddenly stopped, when the secondary strainer lever of the fuel oil in the engine room was adjusted to the correct position, the main engine operated normally.

In order to normally supply fuel oil to the main engine of this ship, the fuel oil strainer lever had to be fixed in the correct position. When examined more specifically, on the main engine fuel oil strainer of this ship, a primary strainer and a secondary strainer were found between the fuel oil service tank and the main engine; two strainers were installed on the left and right, respectively, on the first and second strainers. The lever had to be fixed by selecting one of these two strainers as a lever, and the lever had to be fixed by tightening the grand packing such that it does not move. When tightening this grand packing, since the grooved area of the grand packing was tightened by hitting it with a hammer using a flat head screwdriver, etc., although the lever was in the normal position, the lever could be rotated during tightening of the grand packing, so the lever position had to be confirmed after tightening. When considering these points, the reasons for the blockage in the fuel oil supply and stoppage of the main engine were caused by rotating the lever during the tightening process of the grand packing during the final touches of the fuel oil strainer maintenance work performed by the No. 1 oiler on the day before the accident, by the lever position not being checked after tightening the grand packing, or by the possibility that the fuel oil was not being supplied correctly by rotating the lever due to vibrations caused by the use of the main engine with the grand packing not fully tightened.

However, when aggregated by the facts that the main engine was used hours after the maintenance work was performed on the fuel oil strainer and the grand packing was tightened on this ship, in which the lever was rotated in the process of tightening the grand packing, but the lever position was not confirmed after reassembly, it was judged that, as this ship was operated in the above conditions, the fuel oils in the fuel oil pipe, the secondary strainer, and the small tank installed in the middle of the main engine were all consumed, and fuel oil was no longer supplied to the main engine.

(3) Responsibility for negligence of main engine maintenance for "Ship A"

On a ship, before performing the main work, the chief engineer or the person in charge of the work must educate the workers; before the work, the precautions to be taken when working must be communicated to the workers who have to work on it. In particular, maintenance work on the main engine fuel oil strainer is very important to ensure proper fuel supply to the main engine.

However, on this ship, the No. 1 oiler had to clean the main engine fuel oil strainer alone, and no warnings or instructions about this work were given. Additionally, the chief engineer and the first engineer did not confirm the purpose of the work performed by No. 1 oiler alone.

As a result, as described above, since the fuel oil was not supplied to the main engine of this ship, the main engine stopped during departure from the port, and the ship collided with plying boats mooring at the pier.

Therefore, the cause of this accident case was that the chief engineer in charge of general management of maintenance work and the first engineer in charge of the work neglected to manage and supervise the maintenance work on the fuel filter.

B. Causes of the accident

This collision accident occurred because "Ship A" neglected their maintenance work on the fuel supply system strainer during departure from the port; thus, the fuel oil strainer selection lever deviated from the correct position and blocked the fuel oil supply to the main engine, causing the main engine to suddenly stop.

3. Acts of persons involved in the maritime accident

A. Maritime accident involving Person A

The maritime accident involved person A was the first engineer of "Ship A", who was in charge of the maintenance for the main engine of "Ship A". Therefore, he had a duty to directly manage and supervise the maintenance work on the main engine of "Ship A".

However, as described above, this person neglected to do so and a collision accident occurred, and this person was judged with job negligence.

Therefore, with respect to the conducts of this person, in accordance with the provisions of Article 5 (2) of the "Act on Investigation and Judgment of Maritime Accidents" and Article 6 (1) 2 of the same Act, the duties of this person as a second engineer were suspended for 1 month.

B. Maritime accident involving person B

The maritime accident involving person B was the chief engineer of "Ship A", wjp was in charge of general management for maintenance work on "Ship A". Therefore, although the main maintenance work for "Ship A" was performed by the person in charge, precautions and safety educations were to be implemented before the work was conducted, and he had a duty to check whether the work was completed correctly after the work was performed.

However, as described above, this person neglected their duty and a collision accident occurred; this person was judged with job negligence.

Therefore, due to the conduct of this person, this person shall be reprimanded in accordance with the provisions of Article 5 (2) of the "Act on Investigation and Judgment of Maritime Accidents" and Article 6 (1) 2 of the same act.

4. Lessons for Accident Prevention

A. As the main engine of a ship is the most important apparatus, when performing any maintenance work necessary for the operation of the main engine, it must be performed under the direct control and supervision of the chief engineer or the person in charge, the first engineer.

B. For scheduled maintenance work on the ship, education (a tool box meeting) on safety and precautions when performing the work must be conducted by the chief engineer or the person in charge before performing the work. 5 September 2019

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