The Current Status of Non-Fire Alarms Research

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Abstract

This study investigated the trends of domestic non-fire alarm research through text mining analysis. The titles of 128 papers on the theme of "non-fire alarm" in KCI registered and KCI candidate journals from 1990 to 2024 were analyzed. 345 subject terms were extracted through morphological analysis and visualized through text mining. The top 50 most frequent subject terms were analyzed. Words with high link centrality appeared in the order of "fire detector," "smoke detector," and "non-fire alarm," and most of them were subject terms related to detector performance improvement and technological development. On the other hand, keywords for laws and systems were lacking. In addition, subject terms related to test standards appeared. However, since there are no current laws or systems related to non-fire alarms, and there are no non-fire alarm test items in the management system, it is necessary to introduce laws, systems, and test standards.

Key words: Text mining, non-fire alarm, trend analysis, key words, research status

I. Introduction

In recent years, buildings have become larger, more complex, and taller, and the nature of fires occurring in changing architectural environments has become more complex and more frequent.

Automatic fire detection equipment is a device that detects heat, smoke, flames, and combustion products generated by a fire inside a building at an early stage, displays the location of the fire to those involved in the building, and sounds an alarm. It is an important device for reducing loss of life by notifying victims inside a building of the outbreak of a fire early on, enabling them to evacuate.

Automatic fire detection systems determine the presence or absence of a fire by detecting the by-products of a fire, such as heat, smoke, and flames. Such automatic fire detection systems must recognize and alert on a fire as early as possible in order to maximize the time for victims to evacuate.

Fire detectors detect physical phenomena or combustion products that occur during a fire and sound an alarm when the amount exceeds a predefined threshold. However, if certain conditions are met when a non-fire is detected, it is considered a non-fire (Choi & Hwang, 2022). In other words, it means that there is no problem with the function of detecting fire, but the detector detects a fire due to external factors such as heat or smoke, and the detector activates an alarm or firefighting facilities.

In other words, an increase in false fire alarms leads to fire situations where the fire department in charge is called out even when there is no fire. This leads to problems such as a decline in the reliability of the fire service system and a waste of firefighting power due to false calls. This makes it difficult to respond appropriately in a fire situation, which affects the loss of life and property damage and increases the damage, so measures against false fire alarms are necessary.

We have reviewed studies that analyze the causes of non-fire alarms. Ahn(2002) presented a method for reducing non-fire alarms in photoelectric address-type analog smoke detectors. Jung(2004) presented a method for preventing non-fire alarms through an experiment on automatic adjustment of detector sensitivity. Hong et al.(2004) proposed a heat and smoke combined fire detection system using fuzzy logic with heat and smoke concentration as input variables. Kim(2005) presented the function of non-fire maintenance prevention devices and the use of mobile CCTV from the maintenance and management perspective. Jung(2011) presented problems and solutions through an analysis of operational failure types of sprinkler equipment. Kim(2012) presented a method for adding address functions and improving reliability of automatic fire detection equipment. Roh(2012) explored a method for calculating fire detection time taking into account the characteristics of photoelectric smoke detection. Seo(2017) conducted research on the construction of an IoT-based remote detection system. Park(2018) analyzed the problem of malfunctions in gas instrumentation equipment and proposed a solution. Choi(2021) developed a composite detection system that can determine fire and non-fire by checking the detection characteristics of smoke detectors in fire and non-fire situations using UL 268 standards. Lee(2022) confirmed the characteristics that appear when water vapor flows into the smoke detector. Choi(2022) proposed a detection factor that can determine fire and non-fire alarms. Choi(2023) presented a solution to improve non-fire alarms through UL 268 experiments, smoke detector concentration measurement experiments due to humidity changes, and smoke detector response experiments due to smoke color.

Research on non-fire alarms began around the 20th century. However, there has been no overall research on what research is being done on non-fire alarms. Studies on research trends published so far include Ryu et al.(2021) Analysis of patent trends in fire equipment technology using IoT and ICT technology & Lim(2023) Research trends in the field of fire safety through quantitative information analysis.

Looking at research related to non-fire alarms, we can see that there are studies that present the problems and improvement plans for non-fire alarms through the analysis of literature, laws and standards, current statistics, questionnaires and field survey results, and studies on measures to reduce non-fire alarms through experiments and simulations on detectors, etc. In particular, in recent research, active research has been conducted on IoT and AI intelligent fire judgment and fire detection systems in line with the 4th Industrial Revolution, and in research examining trends in the firefighting field, research trends in the firefighting field are limited to specific technologies and research trends after the 2014 Sino-Japanese War sinking accident, and there are limitations in establishing research directions for non-fire alarms.

Recently, text mining analysis has been widely used as a research model that can comprehensively analyze research trends. Text mining analysis measures the frequency with which languages occur together in the content of communication to determine the symbolic connection structure between languages and semantic interpretation (Park & Leydesdorff, 2004). This analysis method derives the objective meaning of messages through analysis of the relationships between words and applies the structure and principles of the cognitive system to the analysis, minimizing the possibility of subjective interpretation by researchers through the derivation of semanti

c related results and sequential semantic analysis (Yoon & Park, 2015).

Therefore, this study will examine the future direction of non-fire alarm research by examining research trends on non-fire alarms using text mining, a big data research method.

II. Research Methods

1. Subjects of analysis

The search terms "non-fire alarm", "fire detector", "smoke detector", "heat detector", and "automatic fire detection equipment" were used to search for domestic research papers (June 1, 2024) using the KCI paper search service. Duplicate searches were performed for papers and dissertations, titles, keywords, and greens, and papers that were not non-fire alarm related papers were excluded. A total of 128 paper titles were used as the research subject. The title of a paper is understood as the text in which the content of the research and important themes are most concentrated (Park, 2017; Kim et al. 2015). Dissertations were excluded from the analysis due to the previous research of Lee(2015) that there are differences in the type of degree and the level of the degree.

2. Analysis method and procedure

This study used text mining analysis to interpret the relationship between subject terms that appear in non-fire alarm related research. Research trend and topic analysis using text mining can extract unformatted keywords and keywords in a short time, grasp the interactions between concepts, and relatively objectively view research trends and topics by period and topic (Yun, 2020).

Text mining analysis Voyant Tools program was used for main control frequency analysis, density analysis, and connection center line analysis.

The text mining analysis of this study was carried out through the following steps. Prior to the first step, papers were searched using the KCI paper search service as follows. In the second step, 345 main controls that appeared in 128 non-fire alarm related papers analyzed with the Voyant Tools program were extracted and organized in order of frequency. In this study, the top 10% of main controls were selected and used for the overall research trend analysis. In the third step, the connection frequency, density, connection centrality, and betweenness centrality of the language network were performed using the exposure frequency matrix by main control. In the fourth step, the relationships between the main and control words were visualized to make them easier to understand (Kim & Jeong, 2016).

III. Research Results

1. Main control frequency analysis of paper titles

Word frequency analysis is a method of counting the number of times a particular word appears and arranging them in order of frequency. It is used as a basic analysis method, especially in the field of word recognition (Balota and Chumbley, 1984). In this study, we investigated the main control that we want to emphasize in recent flip learning research through main control frequency analysis of paper titles. As a result of analyzing the titles of 128 analyzed papers, a total of 345 words were extracted. The top 10 most frequent words are shown in <Table 1>. As a result of the frequency analysis, the most frequently used word in the titles of the analyzed papers was "fire detector". Next appeared in the order of "smoke detector", "non-fire alarm", and "response characteristics". In other words, it can be seen that words related to automatic fire detection equipment, fire detector, smoke detector, heat detector, etc. are often used in research on "non-fire alarm".

[Table 1] The frequency of Top 10 Key words

Category	Subject	Frequency
1	Fire detector	24
2	Smoke detector	17
3	Non-fire alram	17
4	Response characteristics	12
5	Automatic fire detection equipment	9
6	Heat detector	9
7	Flame detector	9
8	Single alarm detector	9
9	Photoelectric smoke detector	9
10	Plan	6

2. Topic analysis of papers

Topic modeling was conducted on 128 academic papers collected to investigate the core themes of non-fire alarm research. As a result, a total of four theme groups were derived, as shown in Table 2.

The core keywords of each topic are the keywords that have a high probability value in the topic and are representative of the topic.

[Topic 1] has words such as "response characteristics," "smoke detector," "experimental research," "photoelectric smoke detector," and "IOT" as core keywords that appear with a high probability, and was given the topic name "fire detector." [Topic 2] has words such as "response characteristics," "fire detector," "non-fire alarm," "IOT," "heat detector," and "numerical analysis" as core keywords, and was given the topic name "smoke detector." [Topic 3] has words such as "smoke detector," "heat detector," "single alarm detector," "response characteristics," "false axis movement," and "malfunction" as core keywords, and was given the topic name "non-fire alarm." Finally, in [Topic 4], words such as "fire detector," "smoke detector," "photoelectric smoke detector," "experimental research," and "non-fire alarm" appeared as core keywords, and the topic was named "response characteristics."

[Table 2] Topic modeling of paper titles

group	Topic	Keywords
Topic 1	Fire detector	Response characteristics, smoke detector, experimental research, fire detection, photoelectric smoke detector, IOT
Topic 2	Smoke detector	Response characteristics, fire detector, non-fire alarm, IOT, heat detector, measurement, numerical analysis
Topic 3	Non-fire alram	Smoke detector, heat detector, single alarm detector, response characteristics, false alarm, malfunction
Topic 4	Response characteristics	Fire detector, smoke detector, photoelectric smoke detector, experimental research, fire prevention

3. Word Cloud

To make it easier to understand the analysis, a word cloud was created for the most frequently occurring words through a word analysis of the title text of the papers. The most frequently occurring words confirmed through the title word cloud were "fire detector," "smoke detector," "non-fire alarm," "automatic fire detection equipment," and "response characteristics."

[Figure 1]Text mining of words in the titles of non-fire alarm studies

IV. Conclusions

In this study, we analyzed the titles of 128 papers on the theme of "non-fire reports" from 1990 to 2024, extracted 345 subjects, visualized them using text mining, and visualized the linguistic network of the top 50 most frequent subjects using connection centrality performance betweenness centrality. Based on the results of the previous study, we summarized our conclusions as follows and provided recommendations for each.

First, most of the research related to non-fire alarms is about improving the performance of detectors and developing technology. In this study, "non-fire alarms," "smoke detectors," and "response characteristics" appeared as words with high mutual influence. On the other hand, it can be seen that there is a lack of keywords related to laws and systems. Currently, there are no laws or systems related to non-fire alarms, and there is no definition of the term. This has caused problems in communication about non-fire alarms, and regulations such as definitions and classification systems for non-fire alarms are needed. Secondly, main controls related to test standards such as "UL 268" and "ISO 7240-7" appeared from words related to "non-fire alarms." Currently, detector type approval is performed under the detector type approval and product inspection technical standards, and commonly used smoke detectors have been managed by standards such as non-fire security prevention and sensitivity tests in Technical Standards No. 8 and Article 19. However, changes are necessary to adapt to the changing environment. In particular, since there are no test items in the current management system, it is necessary to introduce test standards such as NFPA 72, UL 268, ISO 7240, and EN 54.

This study analyzed the titles of non-fire alarm-related papers through text mining analysis and analyzed the actual overall trends. However, such a main control analysis has limitations in that it cannot analyze research results (Kim et al. 2015). Therefore, as future non-fire alarm research increases and the data size increases, it is believed that an analysis will be possible that can grasp trends in research themes and research methods, including summaries and author training. In addition, since there has been a wide variety of research on fire detectors as a subject of non-fire alarms, research that conducts text mining analysis focusing on "non-fire alarms" is also likely to provide new insights.

The results of language network analysis can generate meanings in various directions depending on the subjectivity of the person interpreting them. Therefore, we hope that the results of this study can be used as material for non-fire insurance researchers to find areas that need research but are lacking and expand the research field.

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