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The Improvement Plan for Fire Response Time using Big Data

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Abstract

CCTVs are already much ingrained into our lives, and can be commonly seen not only in public spaces but also in private ones. Although CCTVs were developed for military purposes at first, nowadays they are used for the purpose of the safety of society. Furthermore, the public sectors such as fire stations, local governments, and the police also make use of CCTVs, and the range of use includes crime prevention, traffic information collection, traffic enforcement, and so on. In other sectors, the use of CCTV for safety in private spaces like apartments, houses, buildings, stores, and elevators is becoming common. Precedent studies on utilization of CCTV, however, mainly focused on legal aspects and parts about crime prevention. Nonetheless, CCTVs are not only for crime prevention, and they are in use for various fields: traffic management, traffic enforcement, disaster, fire management, facilities management, harbor management, and so on. Accordingly, this research aims to suggest in the explorative way the methods for fire prevention and suppression using big data (CCTV), and based on these, new approaches to securing safety against disaster.

Keywords: Big data, CCTV, Fire Response Time

1. Introduction

Fires cause immense damage to all the properties and lives in an instant. As all the disaster situations go, it is also really important to suppress fires at the outbreak. For early suppression of fires, the fire service is called out. Mobilization could be defined as a series of acts from recognition of accidents to arrival of emergency medical services on the scene. General rescue-aid services consist of the following in order: dispatch instruction, selection of fire lanes, and dispatch, and firefighting mobilization certainly includes selection of fire water after dispatch instruction. When selecting fire lanes, moreover, synthetic judgments are made on all the conditions including the shortest path to the scene of a fire, driving conditions, and traffic congestion to decide and proceed[1].

What is important is that fire should be put out within 5~8 minutes since a flashover happens 5~8 minutes after the outbreak of fire; that is to say, the golden time must be secured. A flashover means a phenomenon where the entire interior is in flames and the temperature climbs as time goes by.

CCTVs are already much ingrained into our lives, and can be commonly seen not only in public spaces but also in private ones. Even though CCTVs are used variously in all sectors of the society, there is relatively little interest in effectiveness, efficiency, and problems. Therefore, people are highly concerned about violation of fundamental rights the constitution defines such as portrait rights, secrets and freedom of privacy, and right to informational self-determination. Most of precedent researches about CCTV focused on fire monitoring system, and establishment of fire detection system using images in terms of fire prevention.

Thus this research suggests the system for improving the fire response time through analysis of big data

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(CCTV); with the comprehensive disaster situation room analyzing real-time traffic conditions and circumstances in case of fire to predict the fire response time. This study suggests the establishment of the control system which show the directions and control traffic signal for shortening the time.

2. Theoretical Background and Preceding Researches

Generally, a golden time means the most important time in the initial response of life saving, and fire suppression. A golden time could be different according to disastrous situations, but normally five minutes are set as an objective in fires and medical emergency. For example, the arrival time at the scene of fires is 7 min 48 sec in Gyeonggi-do of 2013 (10th place among 16 cities and provinces across the country), and it is planning to shorten the time to 5 minutes by 2018, and to increase the arrival rate at the scene within 5 minutes from the current 37.3% to 45%[1].

Quick initial correspondence during disasters is the most important factor in reducing life and asset damage that the golden time system, a goal time for disaster correspondence was adopted.

According to analysis results of fire growth curves, serial spreading speed and damaged areas rapidly increase if fire suppression does not start within 5 minutes of fire occurrence. In case of emergency patients with cardiac arrest, survival rate rapidly decreases to under 25% if appropriate emergency measures are not taken within 5 minutes[2].

2.1 CCTV (Closed Circuit Television)

According to Article 2 of the guideline for CCTV installation and operation for personal information protection, CCTVs (closed-circuit televisions) are photographing devices and units of communication equipment. CCTV are installed in certain places and send collected video information through the closed wired and wireless channel for specific people.

Video information is the information to confirm identity of individuals in question filmed by CCTV. Data subjects are people identified by video information, defined as natural people who are the subjects of the video information in question[3].

However, the general concept of CCTV is the method of transferring signal to specific monitors in certain places using video cameras.

2.2 Application of CCTV

By purpose of installation, the application types of CCTV could be usually classified as crime prevention, traffic information collection, speed illegal parking enforcement, facilities management, disaster fire management, harbor management, airport management, and so on[4].

2.2.1 Crime Prevention CCTV

One of the most commonly used types. The application type that is generally accepted.

2.2.2 CCTV for Traffic Flow Surveys

It is not for specific vehicles or individuals, but for real-time monitoring of traffic flow, and does not record video.

2.2.3 CCTV For Traffic Enforcement Such as Traffic Violations

It is used for detecting traffic violations such as overspeeding of vehicles, traffic signal violation, illegal parking, and bus lane violation, and records videos to store them for more than five years or semipermanently.

2.2.4 CCTV for Detecting Wanted Vehicles

The Automatic Vehicle Number Identification (AVNI) system to arrest criminals quickly by identifying vehicle numbers automatically and comparing them with numbers of wanted vehicles.

2.2.5 Etcetera

Night vision CCTV for smuggling detection, CCTV for gun smuggling detection, CCTV for forest fire surveillance, CCTV for curbing illegal trash dumping by using PC, CCTV for protection of buildings and facilities.

2.3 Preceding Researches

Most papers about fire-related CCTV centered on the fire detection technology or a fire predictor such as fire simulation, fire surveillance system, image-based fire detection system, unmanned fire surveillance system.

Park[5] drew the order of importance of disaster management in fire-stations' works, which he organized through the fire academy programs by disaster management steps using Analytic Hierarchy Process with eight specialists[5].

Jeong and Kim[6] identified the present conditions of infrastructure for disaster prevention through

understanding disaster prevention characteristics of Daegu-Kyungbook region. They hypothesized the predicted disaster occurrence, and applied them to the network analysis method in order to build the infrastructure for disaster prevention and management system suited for the real state of regions[6].

3. Study Method and Procedure

In this study, the correlation between present condition of CCTVs and number of occurring fire accidents by building type was analyzed. After definition, analysis methods to use information data for searching alternatives to solve this problem were planned. Open source tool R was then used to realize analysis and visualization and the procedure to interpret this was performed.

3.1 Definition of Problem

Quickly arriving at scenes at fire occurrence within golden time is ideal for fire suppression.

Traffic conditions of roads, unpaved access roads, and narrow roads have problems for 119 EMTs to arrive in the scene of fires quickly. Thus this research aims to look for the method for arriving in the scene of fires rapidly.

3.2 Information Required for Problem

Goyang City is composed of 3 gus which are Deogyang-gu, Ilsandong-gu, Insanseo-gu. A total of two fire stations are installed in Goyang Fire Station and Ilsan Fire Station in which Goyang Fire Station is in charge of Deogyang-gup and Ilsang Fire Station is in charge of IlsanSeo-gu. Therefore there is need to ascertain which regions require additional CCTVs for enforcement according to the current status of fire occurrence by industry, and of CCTV installation.

3.3 Data Required to Derive Information

Related data is required to derive information needed to recognize problems. Present conditions of CCTV installation check by gu and fire accidents by gu.

3.4 Analysis Method to Derive Information

Visualization using pie charts to find rates by analyzing present condition of fires by each gu will be performed and Goyang City, Gyeonggi-do, South Korea will be set as the subject of analysis.

Also, cluster analysis and time series analysis by dwelling and industry and cost of damage was performed to understand the necessity of CCTV installation by number of occurring fire accidents.

Data is first collected and the data was organized through preprocessing procedure for analysis. Only data required for analysis was gathered to make one new data group subject to analysis. Lastly, analysis tool R was used to calculate desired information.

4. Data Collection and Analysis

4.1 Data Collection and Preprocessing

Data required for analysis can be found in Table 1.

Table 1. Source of data collection

Public Data portal	http://www.data.go.kr
The City Hall of Goyang	http://www.goyang.go.kr
Government 3.0	http://www.open.go.kr

Data of present condition of fire accidents and car registration could be obtained through the national statistics portal, in addition, necessary data were obtained through information disclosure requirement. Collected data was preprocessed and changed into analyzable form and the data used in analysis was transformed into csv for analysis use.

Also for cases where address information exists but no coordinate information is available, a coordinate conversion program was used to trace coordinates to complete the preprocessing.

4.2 Awareness of Present Condition of CCTV Installation and Fire Accident

First of all, data of Goyang city was analyzed through R to know the current status of fire occurrence.

4.2.1 Time Series Analysis

This is the time series analysis of property losses due to fires from Jan. 2008 to Jun. 2015 in Goyang-si, Gyeonggi-do. The fire data of Deogyang-gu, Ilsandong-gu, and Ilsanseo-gu of Goyang city were averaged by each quarter (three months) to visualize them in graphs.

As shown in the graphs, the cost of property damage is gradually increasing; so this research is intended to find the method of minimizing damage by analyzing the fire data in order to reduce property losses.

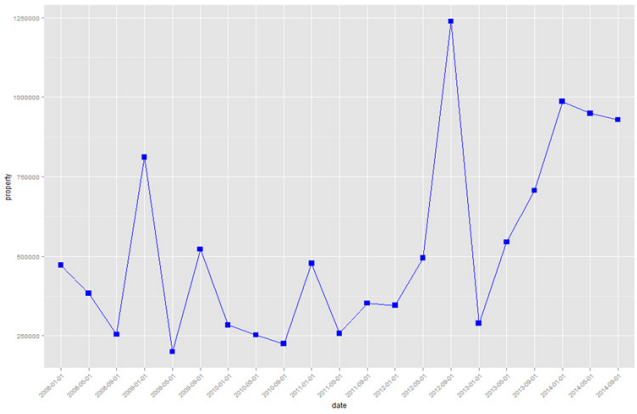


Figure 1. Time Series Analysis.

4.2.2 Pie Chart

Property losses in each place were visualized in the pie chart. As shown in the visualization, it is ascertained that outbreaks of fire in industrial facilities make the most property losses. Industrial facilities include factory facilities, animals and plants related facilities, workshops, and storage facilities.

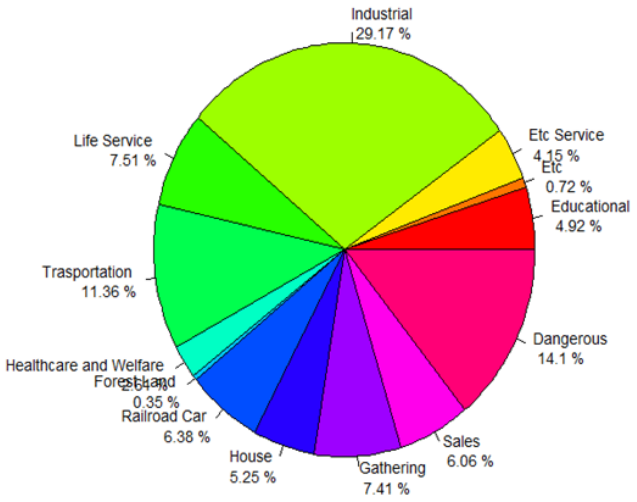


Figure 2. Pie Chart.

4.2.3 Bar Chart

(a)

The visualization indicates which ones of industrial facilities had the most fire damage; the left part is the total cost of property losses in each place, and the right one is the average cost of property losses in each place. As shown in the bar graphs, it seems that the property losses in factory facilities are most devastating.

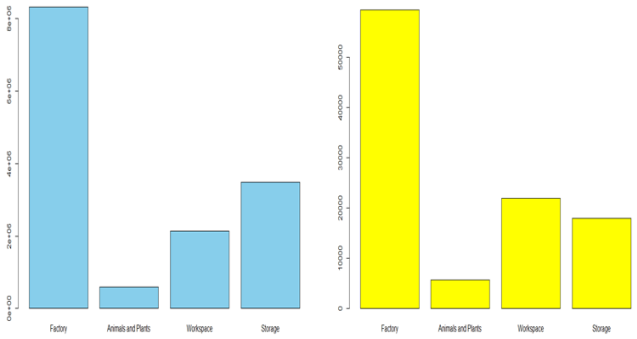


Figure 2. Bar Chart.

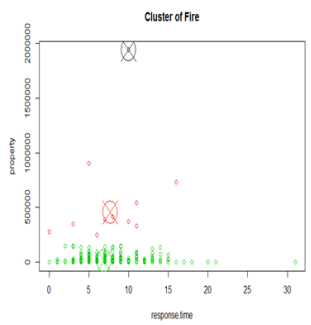
(b)

4.2.4 Cluster Analysis

Three non-hierarchical cluster analyses were carried out; the characteristics of fire damage were identified through clusters, and it turned out that all the clusters take more than five minutes of the fire response time.

When looking at the left picture, many figures are in lower positions as if property losses are small, but the average of property losses in industrial facilities is 27,156,300 won, a very high figure. In the case of factory facilities, the fire response time is more than six minutes on average; the average distance from fire stations is 7.55km, and 5.628km from 119 safety centers.

As for industrial facilities, since they are established in outskirts of cities, it takes a long time to respond at outbreak of fire.

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Cluster means:
    property response.time fire.station fire.house
1 1936867.00      10.000000     8.20000   7.300000
2  457778.30       7.700000     9.50000   6.750000
3   15293.84       6.919847     7.51145   5.603435

> summary(result)
    property        response.time   fire.station    fire.house
 Min.   :    0.0   Min.   : 0.00   Min.   : 0.00   Min.   : 0.000
 1st Qu.:  481.5   1st Qu.: 5.00   1st Qu.: 5.00   1st Qu.: 3.500
 Median : 2957.0   Median : 6.00   Median : 7.00   Median : 5.100
 Mean   : 27156.3  Mean   : 6.94   Mean   : 7.55   Mean   : 5.628
 3rd Qu.: 16192.5  3rd Qu.: 9.00   3rd Qu.:10.00   3rd Qu.: 7.500
 Max.   :1936867.0 Max.   :31.00   Max.   :21.00   Max.   :19.000
```

Figure 3. Cluster Analysis.

4.3 Plan to Improve Fire Response Time through CCTV

The results of analysis of big data ascertained that among fire accidents in Goyang city the outbreak of fire in industrial facilities caused the worst damage. The reason for this is that the industrial facilities were located in

suburbs of cities with a long distance from fire stations and safety centers, so that the fire response time gets longer.

Moreover, it was learned that industrial facilities have equipment and materials inside which could lead to a large amount of damage at outbreak of fire. Not only industrial facilities are located in outlying areas, but also the access roads often happen to be unpaved and very narrow, making difficult to get in. If there are illegally parked vehicles on the roads, it is almost impossibly narrow to go in.

In 2013 Incheon city ran the project where it selected major base stations among about 3000 base stations of three mobile telecommunication companies located in Incheon, installed CCTV for fire and disaster detection, and built the situation management system connected with the 119 emergency control center. Seoul city is also mounting the efforts to secure the safety of citizens against fires and disasters by drawing up the safety map of fire-fighting.

The safety map of fire-fighting, the digital operation system where the Seoul disaster management center and the 119 emergency control center could manage and control the scenes, contains all the information about the present condition of each building, satellite pictures around accident sites, the width of roads that allows fire trucks, and locations of fire water in facilities.

Through this, the response time could be shortened, and the efforts keep being expended to protect precious lives and properties of citizens from fires and disasters through preemptive response strategies. Goyang city appears to need the method for reducing property losses by securing fire access roads, and minimizing the response time at outbreak of fire through building cooperation of vehicles based on the peripheral notification control system.

5. Conclusions

Since a lot of CCTVs are installed lately, many changes have taken place in our daily lives. In particular, they are used in the various fields of disasters such as crimes, traffic management, traffic enforcement, disaster fire management, facilities management, harbor management. However, most public CCTVs focus on crime prevention and traffic enforcement while private CCTVs focus on facilities management and crime prevention management.

This study uses public data to propose a plan to improve the Fire Response Time through CCTV in Goyang City. First, real-time corresponding of urgent situations such as fires by building a CCTV operation management systems. Not only Goyang City, but other autonomous districts can expect improvement of golden time arrival during fire accidents.

Second, drawing up of the safety map of fire-fighting seems needed which includes all the information about the present status of each dwelling and industry, road traffic conditions, satellite pictures around accident sites, the width of roads that allows fire trucks, and locations of fire water in facilities.

However in this study, there are many restrictions in realizing the proposed alternative. The analyzed data was simple public data that variables are limited. Various variables such as type of dwelling and industry time of departure to fire scene must be complexly considered for CCTV installation, but only public data was used in this study for analysis that limitations exist.

Future research would need the big data planning methodology which is more specific and feasible with an effort to secure diverse raw data, and studies using various big data analysis methods should be conducted.

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