# A Real-time Disaster Situation Mapping System for University Campuses

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**Abstract.** This paper proposes a real-time disaster situation mapping system for campuses. University campuses have various features and issues (*e.g.,* difficult to determine the number of people on campus at any one time as there are many students studying at the library or in their rooms, visitors can also use the open spaces, building layouts are often very complicated etc.), and therefore unique disaster prevention efforts are required. In order to address these prevention issues, a system that facilitates disaster situation information transmission by users will be effective. PlaceEngine is implemented for this system to allow users to estimate the current location easily by utilizing Wi-Fi devices.

**Keywords:** disaster prevention, campus map, situation information gathering, PlaceEngine, social media.

## 1 Introduction

There has been great improvement in various disaster (*e.g.,* capital earthquakes directly above their epicenters) prevention countermeasures and their researches for more than a decade. However, most of the countermeasures that have been implemented are classified as "Kojo" which are implemented by public sectors (in Japanese), therefore, it is considered that the importance of both "Jijo" (countermeasures implemented by the individual) and "Kyojo" (countermeasures implemented by mutual assistance) is increasing [1]. University campuses are one of the prime examples of places that require Kyojo (mutual assistance).

In order to assist better evacuation, current situation information of each site is useful, and in most cases, the latest information of each site is grasped by people who were just there. The current situation of each site is necessary not only for evacuation, but also for administering first aid or relief operations. However, not all buildings are closely packed together on campuses, and that may create difficulty in gathering situation information inside the campuses. Under these conditions, a system that facilitates disaster situation information transmission by users (students, staff, faculties, visitors) will be effective. It facilitates supporting people to evade danger, and facilitates support of disaster countermeasures offices to grasp the situation of the many places on campuses. The system proposed in this paper was designed and

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prototypes were developed for such needs for real-time information sharing during disasters. In order to stimulate mutual assistance, information infrastructures are required. “Recent disasters highlight the importance of social media supporting critical information gathering and dissemination efforts by members of the public” [2]. Recently, social media such as twitter have been effective for disaster evacuation or rescue [3], but these need to be even more effective to gather disaster situation information, categorize them and visually show them on maps. The real-time disaster situation mapping (RDSM) system proposed in this paper can function as one of the social media.

## 2 Background

As mentioned previously, the need for mutual assistance seems to be increasing, because in actual fact many people survive in times of disaster by mutual assistance. In this chapter, disaster prevention works are reviewed and classified from several perspectives (Table 1). Related papers were extracted that matched the specified criteria: those that examined disaster prevention, those that developed an information system, and those whose publication date is post the Great Hanshin Earthquake (Jan.17, 1995). Twenty six papers were extracted using this process [4]-[30]. Public sectors are the overwhelming majority for target users of the system, one paper targets citizens, and two papers target schools or companies (Table 1 (a)). For assistance type, Kojo (assistance by public sectors) is the overwhelming majority (72.1%), and only five papers dealt with Kyojo (mutual assistance) (Table 1 (b)). More than half of the papers dealt with disaster a priori (Table 1 (c)). For the area scope, “broad” (area includes public sector) has the highest percentage (84.6%), and “medium” (schools, shopping center etc.) occupies only 15.4% (Table 1 (d)). As seen above, disaster prevention systems are mainly targeted at public assistance from the public sectors across broad areas. The RDSM system proposed in this paper targets university campuses whose area scope is medium sized, and Kyojo (mutual assistance) because mutual assistance is effective for this scope. Considering the accessibility and role of social media, common devices (mobile phones, PCs) are adapted to the RDSM system.

## 3 Requirement for Campuses Disaster Prevention

University campuses have various unique features and issues when considering disaster prevention. For example, it is difficult to determine how many people there are on campuses. There will be many students studying at libraries, spare rooms, or cafeterias. Visitors can also use the open spaces. Issues with places also exist. The layouts of buildings are often very complicated. They differ depending on when they were built, and construction of buildings differs by research field. Sometimes public roads cut through the campuses. Some campuses are located on inclined ground. Layout of the rooms (*e.g.,* classrooms, experimental laboratories, practical rooms etc.) is not always familiar, therefore, arriving at one's destination is sometimes not easy. In addition, administrative structural issues exist, which are also different from those

in companies. On-campus disaster countermeasures offices will be set up in times of emergency. However, not all buildings are closely packed together in campuses, and that may cause difficulty in gathering situation information inside the campuses. Under these conditions, a system that facilitates disaster situation information transmission by users (students, staff, faculties, visitors) will be effective. It facilitates support of people to evade danger, and it facilitates the support of disaster countermeasures offices to grasp the situation of many places on the campuses. This system compensates for the area not covered by the public sector (national response system) (Figure 1).

**Table 1.** Classification of Disaster Prevention Related Works

| (a) Target users | | | (e) Point of use | | |
|---|---|---|---|---|---|
| Substances | Number of papers | Ratio (%) | Substances | Number of papers | Ratio (%) |
| Public sectors | 23 | 88.5 | Outdoor only | 19 | 73.1 |
| Citizens (individual) | 1 | 3.8 | Outdoor / Indoor | 5 | 19.2 |
| Others (*1) | 2 | 7.7 | Indoor only | 2 | 7.7 |
| Total | 26 | 100.0 | Total | 26 | 100.0 |
| (b) Assistance type | | | (f) Equipment used | | |
| Substances | Number of papers | Ratio (%) | Substances | Number of papers | Ratio (%) |
| Kojo (Assistance by Public Sector) | 19 | 71.2 | PC・mobile-phone (via Web browser) | 15 | 57.7 |
| Kyojo (Mutual assistance) | 5 | 19.2 | Special-purpose terminal | 11 | 42.3 |
| Jijo (Self assistance) | 2 | 7.7 | | | |
| Total | 26 | 100.0 | Total | 26 | 100.0 |
| (c) System operating point | | | (g) Adapted technology | | |
| Substances | Number of papers | Ratio (%) | Substances | Number of papers | Ratio (%) |
| A priori (first response) | 15 | 57.7 | GIS・web-GIS | 17 | — |
| A priori | 7 | 26.9 | Wireless sensor | 6 | — |
| A priori and a posteriori | 4 | 15.4 | GPS | 4 | — |
| A posteriori (reconstruction support) | 0 | 0.0 | Others (QR Code, etc.) | 1 | — |
| Total | 26 | 100.0 | Total | 28 | — |
| (d) Area scope | | | | | |
| Substances | Number of papers | Ratio (%) | | | |
| Broad (Area includes public sector) | 22 | 84.6 | | | |
| Medium (Schools, Shopping center etc.) | 4 | 15.4 | | | |
| Narrow (Home, Private concern) | 0 | 0 | | | |
| Total | 26 | 100.0 | | | |

(*1) Companies, Schools, etc.
(*2) Ratio is not applicable because some papers deal with more than one technology.

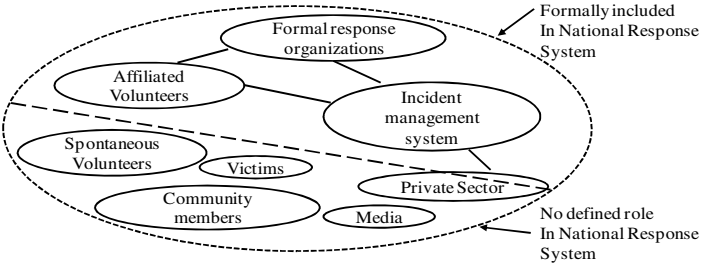


**Fig. 1.** Positioning of Disaster Prevention Systems [31]

# 4 Real-time Disaster Situation Mapping (RDSM) System

## 4.1 Overview

The Real-time Disaster Situation Mapping (RDSM) system is a web based system that can handle disaster situation information on the campuses by the level of detail, such as classrooms or laboratories in the school buildings. The RDSM system can aggregate the information that is sent by users (informers), store it in a situation database on the server and display a disaster situation map to users on request. Assumed users are people staying on the campus and disaster staff of countermeasures offices (Figure 2, Figure 3).

## 4.2 Service Conditions of RDSM System

The RDSM system is developed based on the following service conditions:

- Disaster type: The RDSM system mainly targets the countermeasures for earthquakes. The quake damage assumed that buildings on campus were not fully but may partially destroyed, and mobile devices (PC or phone) are in use and connected to servers inside the campuses or other campuses located remotely.

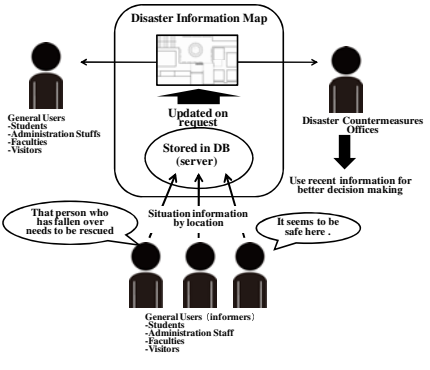


**Fig. 2.** Overview of System Use

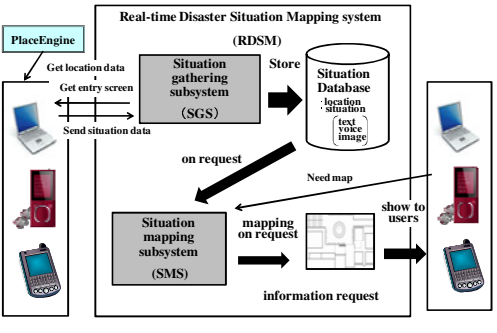


**Fig. 3.** System Flow of RDSM

- Place of use: People can access the RDSM system from inside the building on campuses, and they can also access it from outside of campuses such as from evacuation centers. Although the RDSM system is developed for campuses, this system can be used for facilities that have similar features to campuses.
- Targeted users: People such as students, administration staff, faculties, and visitors are assumed to be informers. People who are assumed to use maps are disaster countermeasures office staff, in addition to people listed as informers above.

### 4.3 Subsystems of RDSM and Functions

The RDSM system consists of two subsystems: the "situation gathering subsystem (SGS)" and the "situation mapping subsystem (SMS)".

**Situation gathering subsystem (SGS).** The situation gathering subsystem (SGS) facilitates the support of people on the campus to send situation information (*e.g.,* safety or danger, damaged situation) of the location where they are staying at that time, using mobile devices (PC or phone). Informers can access the disaster situation entry screen (Figure 4). Their location information (degree of latitude and longitude) can be specified by PlaceEngine [32]. PlaceEngine is a service that allows users to easily estimate the current location by utilizing Wi-Fi devices. Users can send situation information from the "situation data entry screen" by selecting an answer from check boxes or radio buttons. A free description column is prepared if required. Speech to text transformation is feasible using w3voice [33]. "w3voice skeleton" is a development kit for voice-enabled Web applications. Voice data and image data as well as movie data are also available for sending (Figure 5).

**Fig. 4.** Entry Screen (SGS)

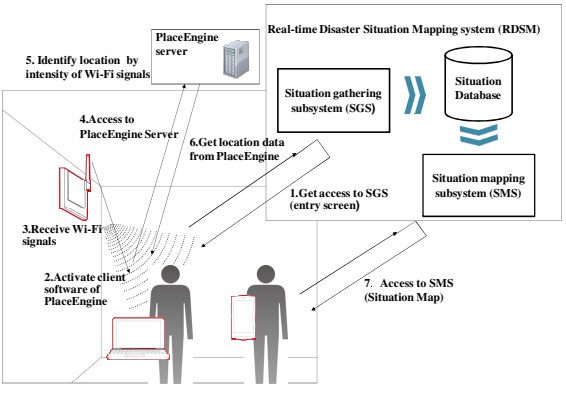


**Fig. 5.** Location Data Acquisition Scheme by PlaceEngine

Location information (degrees of latitude and longitude, or name of the place at which the informer is staying) can be identified by manual entry; in addition, automatic acquisition of location information is feasible by using PlaceEngine. By this function, users (informers) can send location information, even if they do not recognize their location. Entered situation data are stored in databases.

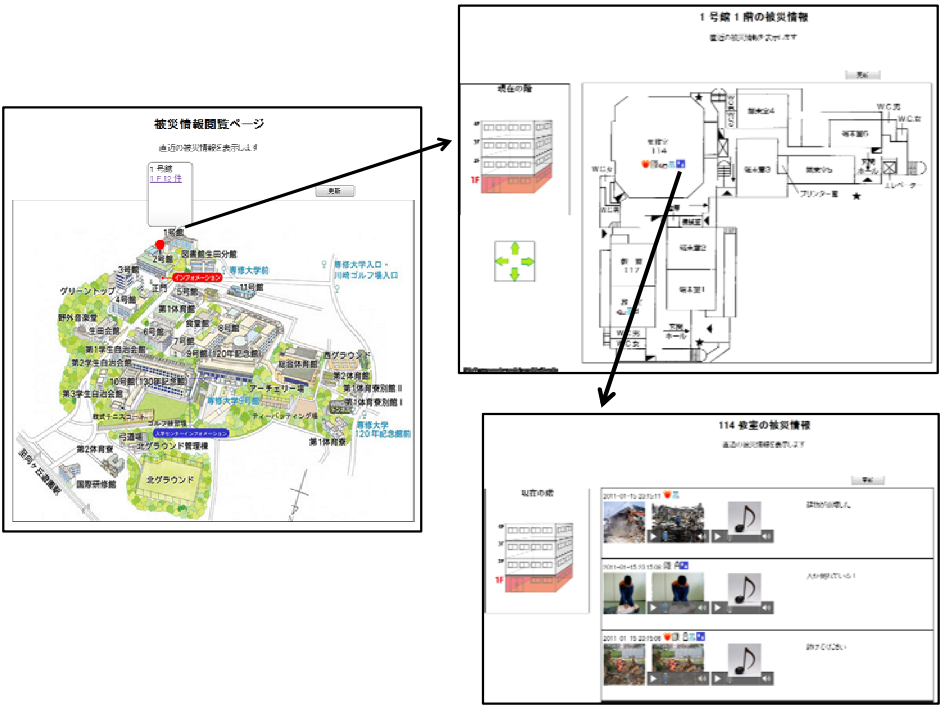


**Fig. 6.** Screens of SMS

In order to set up PlaceEngine for automatic acquisition of location information (degrees of latitude and longitude) the following requirements must be met:

- Access point data of Wireless LAN are saved in the database of PlaceEngine.
- At least one access point is reachable from the place where the informer is staying.
- Access to the PlaceEngine server is feasible.
- Mobile devices (PC or phone) are equipped with Wireless LAN (Wi-Fi) equipment
- Client software is installed on the mobile devices (PC or phone) of the informer.

Location information (degrees of latitude and longitude or place name) can be registered by each access point, so identifying places such as classroom or hallways is feasible because there are many access points of wireless LAN on campuses.

**Situation mapping subsystem (SMS).** The situation mapping subsystem (SMS) reflects situation data that are transmitted by users onto maps. It reads data of the situation database that is updated by SGS on request from users. Maps are composed of three levels: overall campus map level (it presents a birds-eye view), building and floor map level, and detailed information of disaster situation by room type (*e.g.,* classrooms, offices, laboratories) level. The situation information amount is displayed at the overall campus level (Figure 6). By clicking a certain building on the overall campus map, a building and floor map appears. Disaster situation information such as fire, rescue required, building damaged, property destruction, and flood damage is shown by icons. The time when those situations were informed is also shown on this

level map. By clicking a certain room on the buildings and floors map, detailed information of the disaster situation is shown. Detailed information is displayed by time-series on this screen, and voice data or image data are available for access here.

The map displayed in the situation mapping subsystem (SMS) can be created from existing map image data that are used for university brochures. The existing map data would be transformed to png format. Situation data that are described or depicted by text data or icons are rendered on this png map. In order to insert disaster-affected points on the map, obtained degrees of latitude and longitude of two different points (place) from Googlemaps are used. By calculating the distance between users' location and the point obtained from Googlemaps, users' location is identified from the reduced scale distance that is started from two different points.

### 4.4 Significance and Features of RDSM System

The significance and features of RDSM system are as follows:

- Assists users (students, staff, faculties, visitors) in evacuation or rescue: Since the RDSM system is a web based system and uses common mobile devices (PC, phone), users can find out the latest information of a disaster situation (*e.g.,* safety or danger, damaged) according to location easily. PlaceEngine was adapted to assist users in locating and entering their position. Users can choose disaster situation information from options on the screen, instead of having to type everything about the situation they want to convey; however, users can send text data, voice data, and graphic data to the server, if necessary.
- Assists the disaster countermeasures office inside/outside the campuses: Although countermeasures office staff inside the university need to gather situation information, it is difficult to keep tabs on the situation overall because of the limited human resources. The RDSM system can cope with this problem by gathering information on the places from the people who are actually there.
- Available for use in everyday situations (not just in times of disaster): It is often said that disaster prevention systems do not work in times disaster because the users are not used to operating them. The framework of the RDSM system is effective for everyday situations in the universities, for posting event notifications, maintaining buildings, and so forth (this idea was obtained through feedback from administration staff in the university).

In addition to the features mentioned above, disaster situations (fire, rescue required, building damaged, property destruction, and flood damage) are indicated by icons, in order to improve usability. The latest situation data is presented on the map face; however access to time series data is also available for cases where information of the degree of situation change is required. This feature is practical for assisting with rapid rescue, or preventing the damage from spreading.

To ensure the communication environment in times of disaster, a backup system at remotely-situated campuses of universities is recommended.

## 5 Conclusion and Future Works

As mentioned in previous chapters, the RDSM system facilitates assistance of general users (students, staff, faculties, visitors) and disaster countermeasures office on campuses for effective evacuation and rescue. Thus, the RDSM system facilitates Kyojo (mutual assistance) that is expected to reduce disaster damage, and it can play the role of a social media.

The RDSM system is an updated version of a disaster mapping system that was developed by the Yoshida-Iizuka Project 2009 in Senshu University. Comments from attendees of the project exhibition were as follows: The majority of comments were "It makes us feel safe should a disaster occur", and "It must be available for various sites on campuses" was also heard often. For agita factors, comments such as, "feel anxious about the communication environment in times of disaster", "worry about mischief and malevolent literature", "information security must be considered", were heard. The RDSM system is also premised for use in everyday situations, so this answers the comment "It must be available for various situations on campuses". RDSM is not supposed to save personally identifiable information. However, if the requirement for dealing with personally identifiable information appears in the future for reasons such as corresponding to the need for urgency, authority setting for accessing data must be carefully considered. Countermeasures for mischief and malevolent literature are not considered now, however, the analysis function of informed data by comparing time series data or data of the surrounding area, is recognized as one of the items to be considered. When considering the "feel anxious about the communication environment in times of disaster" comment, the communication environment is not always completely destroyed by disaster as shown when the communication environment was restored on the day following that of the Great Hanshin-Awaji Earthquake (Magnitude:7.3) in 1995 [6]. By setting up a backup system at remotely-situated campuses of universities, ensuring the communication environment becomes more feasible. Crowd computing would be effective for the universities that do not have remotely-situated campuses. Customizing for each university, upgrading the control panel of RDSM system is planned in order to allow flexibility of controlling system parameters such as disaster emergency level. The input screen of the building layout can be improved to facilitate use. Even though the operating systems that are supported by PlaceEngine are currently limited, they will be widespread in the future. By improving these factors, the role of the RDSM system as social media will be more firmly established.

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