A STUDY ON THE DISASTER INFORMATION COLLECTION SUPPORT SYSTEM, INCORPORATING INFORMATION AND COMMUNICATION TECHNOLOGY

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ABSTRACT:
We have developed a support system to facilitate the rapid and effective collection of disaster information, and we have conducted operational experiments to test the system in Tokyo, Japan. We have named this system the Disaster Information Collection Support System (DICSS); it incorporates the Geographic Information System (GIS) and Information and Communication Technology (ICT). We have added additional functions to the DICSS in order to increase the efficiency of investigation, such as an information sharing function using ad hoc network technology, an information collecting function using a middle-distance laser rangefinder, and an information sharing function using a radio frequency identification (RFID) tag. This improved system is a simple and user-friendly GIS specialized for collecting disaster information; it has been designed so that anyone can use it. It can change the specific data under investigation to accommodate the requirements of each individual situation, from quick inspections to rapid assessments of the safety of buildings to detailed investigations for academic purposes. When a public communications network is rendered nonfunctional by a disaster, the system is capable of securing communication between terminals by ad hoc network. It can collect information on the damage caused to a remote location from an elevated position by using laser rangefinder binoculars. We applied this system to an experiment conducted in Tokyo, Japan and confirmed its validity and effectiveness.

KEYWORDS:
Information Collection, Disaster Inspection, GIS, Laser Rangefinder, Ad Hoc Network, GPS

1. INTRODUCTION

Since the 1995 Kobe earthquake, the national and local governments of Japan have developed systems for information collection during earthquakes, such as the Disaster Information System (DIS) developed by the cabinet office of the government of Japan, the REaltime Assessment of earthquake Disaster in Yokohama (READY) of the city of Yokohama, and the estimated seismic intensity map of the Japan Meteorological Agency (JMA). However, it is important to keep in mind that the actual damage caused by an earthquake could be different from the estimated damage. If we rely on only the estimated information, the emergency response may be inadequate. On the other hand, the estimated information can be useful in locating the most severely affected areas at the initial stage of the damage investigation. With all of this in mind, we have proposed a real-time system for collecting earthquake damage information (Shibayama et al., 2002 [1]). In this paper, we will introduce the details of this novel system and explain the results of the field experiments undertaken to check the effectiveness of the proposed system.

2. THE DISASTER INFORMATION COLLECTION SUPPORT SYSTEM, INCORPORATING INFORMATION AND COMMUNICATION TECHNOLOGY

2.1. The Main Features of the System

As shown in Figure 1 and Photo 1, we have developed the Disaster Information Collection Support System (DICSS) to efficiently perform the collection, transmission, and consolidation of actual data pertaining to areas affected by a disaster utilizing Information and Communication Technology (ICT) equipment (e.g., tablet PC, Global Positioning System (GPS), ad hoc network, and laser rangefinder). The DICSS was developed based on two existing systems: an efficient system for acquiring earthquake damage information by Shibayama et al. (2004) [2] and a disaster information collection terminal developed by Zama et al. (2001) [3]. Additional functions to increase the efficiency of the investigation were also added to the system, such as an information sharing function using an ad hoc network, an information collecting function using a middle-distance laser rangefinder, an information sharing function using a radio frequency identification (RFID) tag, and a simulation coordination function.

The main features of the proposed system are as follows:

・This system is a simple and user-friendly GIS specially designed to collect damage information;

・The input to this system can be changed depending on the purpose of the investigation.

・The system imports data in standard vector and raster data formats.

・The system can be accessed using a personal computer, without the need for any special equipment.

・The combined system can determine a worker's present position using the connected GPS.

・It facilitates the collection of data on the damage sustained in a remote location from an elevated position by using laser rangefinder binoculars.

・When a public communications network is rendered nonfunctional by a disaster, it can secure communication between terminals by ad hoc network.

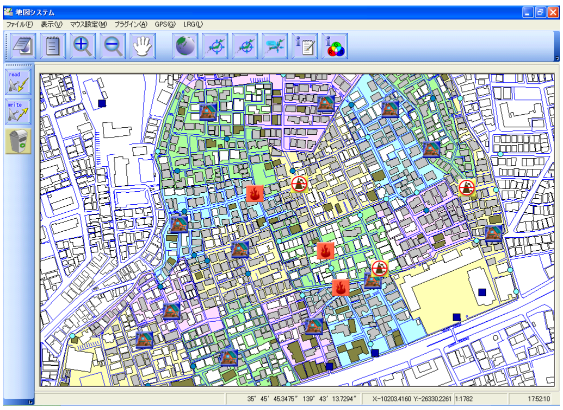

Figure 1 Main window of the system.

Photo 1 Example of extended system (Tablet PC).

2.2. The Configuration and Function of the System

2.2.1 The system configuration

As shown in Figure 2, the DICSS consists of a basic system and any additional systems. The basic system was developed in the GIS engine of ESRI MapObjects LT 2.0 and Microsoft C#.NET, which have all the tools necessary for creating and maintaining a GIS, and an interface designed for indoor and outdoor use. The basic system can be used to manipulate the map display, display data using classifications, pan and zoom through multiple map layers, manage a database of collected data, import external data, and export collected data.

Additional functions can be added to the basic system to increase the efficiency of the investigation, such as an investigator's navigation function using GPS, an information sharing function using ad hoc communication, an information collecting function using the middle-distance laser rangefinder, and an information sharing function using an RFID tag. It is possible to develop these additional systems using Microsoft C#.NET or Microsoft VisualBasic.NET, and the user can use some other system to develop the additional systems.

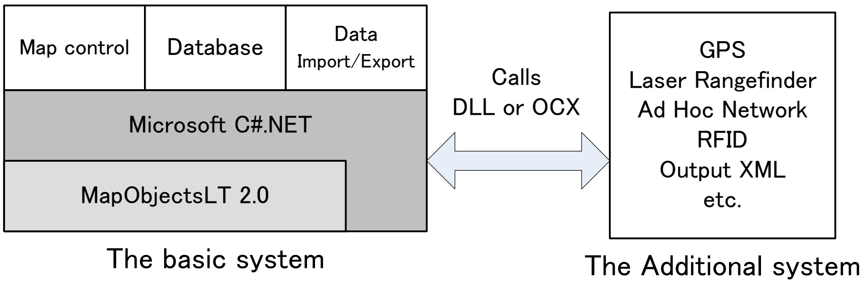

Figure 2 Concept chart of the system configuration.

2.2.2 The system equipment

The DICSS software license is available free of cost and is open to public use. In addition, common personal computers can be used to run it—no special equipment is required. Thus, it is possible to collect damage information by assembling many volunteers for data collection following an earthquake. The personal computer used for data input can be a desktop, a laptop, or a tablet (see Photo 2) depending on the purpose and situation. For example, a laptop PC or tablet PC is appropriate in the field, whereas a desktop PC is more appropriate in an office. The minimum requirements of the current system are compatibility with a Pentium or higher CPU, a 16-bit high color screen adapter with a resolution of 1024 × 768 or higher, and a keyboard or other input device (mouse, tablet, etc.). This system can be run on Microsoft Windows 2000, Windows XP, or Windows Vista. The minimum RAM size is 256 MB for Windows 2000, 512 MB for Windows XP, and 1 GB for Windows Vista. The minimum hard-disk space required to run the system is 200 MB, although it could be more, depending on the size of the digital maps used.
The DICSS configuration can be extended utilizing various peripheral ICT equipment such as a head-mounted display (HMD), GPS, digital communications terminals, or a digital camera. For example, a HMD frees a user's hands to more efficiently input data (see Photo 2, right). The combination of GPS and the digital map can be used to navigate the target area—an extremely powerful tool for a person who is unfamiliar with the area. Currently, the system is compatible with handheld GPS receivers; however, digital communications terminals such as cellular phones or wireless LANs can be used to transmit the data to the disaster headquarters.

Photo 2 Example of the system equipment. Left: Tablet PC. Right: Tablet PC and HMD.

2.2.3 Data import/export

As shown in Table 1, the DICSS is able to be used in various fields and is compatible with many different map

formats. This system supports formats for imported data in the form of vector maps ranging from standard GIS formats (ArcInfo coverages and ESRI shapefiles) to computer-aided design (CAD) formats (DXF, DWG, and DGN) and raster image formats (GeoTIFF and JPEG image compression). This system can export map images in raster image format (JPEG image compression).
The system uses ASCII data formats (XML, CSV, and TEXT) to input and output the investigated data. The investigation data that are output are compatible with various systems such as the disaster countermeasures system, the fire spread simulation system, and the evacuation simulation system.

Table 1 Data import/export

	Data format	Data format type
Import	Vector map data	ESRI ArcView Shapefiles(*.shp) ESRI Arc/Info Coverages(*.e00) CAD Format(*.dgn, *.dwg, *.dxf)
	Raster map data	GeoTIFF(*.tif), JPEG(*.jpg)
	Investigation data	XML(*.xml), CSV(*.csv), TEXT(*.txt)
Export	Vector map data	None
	Raster map data	JPEG(*.jpg)
	Investigation data	XML(*.xml), CSV(*.csv), TEXT(*.txt)

2.2.4 The basic input data (location, properties, and damage grade)

The basic input data of the DICSS are as follows:

a) Choice of damage type (building damage, road damage, or damage due to fire, selected from the side panel of the DICSS)
b) Locations of the damaged objects or areas (e.g., building, area, road)
c) Information on the damaged objects or areas

Upon locating a damaged building, road, or area, we first choose the nature of damage; it can be a damaged building, a damaged road, or damage due to fire, each of which can be chosen from the side panel (see Figure 3, left). Second, we click on its location on the digital map. Third, we input information on the object's properties. After we choose the location, a pop-up window appears, from which one may choose the object type (see Figure 3, right), including construction material (e.g., wooden, steel, reinforced concrete or other), use of the building (e.g., residential, industrial, or commercial), damage grade (e.g., minor, major, or complete collapse), and casualties. Finally, after checking the confirmation window, which shows the all input items, we click the "yes", "no", or "cancel" button.

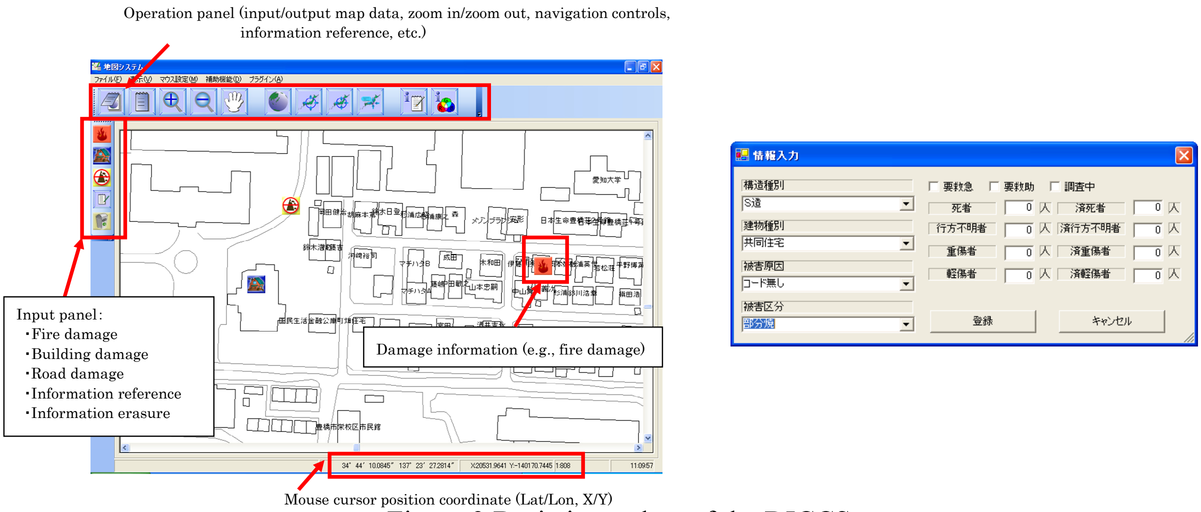

Figure 3 Basic input data of the DICCS.
Left: Main window. Right: Input window for damage information.

2.2.5 The utilization of variably presented information

Using this system, we can change the input contents according to the requirements of the investigation. For example, we may require an immediate estimate of the overall damage in the affected areas after a large earthquake. In such a case, speed is more important than accuracy. On the other hand, inspecting the safety of damaged buildings requires us to carry out more detailed investigations. Accordingly, this system can provide various investigation menus ranging from simple to detailed. An academic investigation of structural damage is one example of a case that would require a detailed menu. For this purpose, we use the chart for describing building damage patterns proposed by Okada et al. (1999) [4] and Takai et al. (2001) [5].

2.3. The Information Collecting Function using a Middle-distance Laser Rangefinder

As shown in Figure 4, we have developed an additional function that uses a middle-distance laser rangefinder to collect information on fire and building damage from an elevated position (e.g., high-rise office building, steel tower, or other) or from a distance.
This system has the following features:
・Ability to locate the area where the damage occurred from an elevated position or from a distance
・Ability to help ensure the investigator's safety from a fire or secondary disaster because of its capability of remote data collection
・Ability to collect information on damage over large areas in a short time
・Ability to be used from a motorcycle, car, or helicopter
This additional function requires a hardware configuration that consists of a PC (e.g., Laptop or Tablet PC), the laser rangefinder, and a data cable. In this experiment, the laser rangefinder used a VECTOR IV from Vectronic that can measure range, azimuthal angle, and vertical angle. To use this system, input the locations of the origin form a GIS screen. The distance and the azimuthal angle from the starting point to the object are then measured using the laser rangefinder, and the object is displayed on the GIS screen. Finally, information on building and fire damage is input.

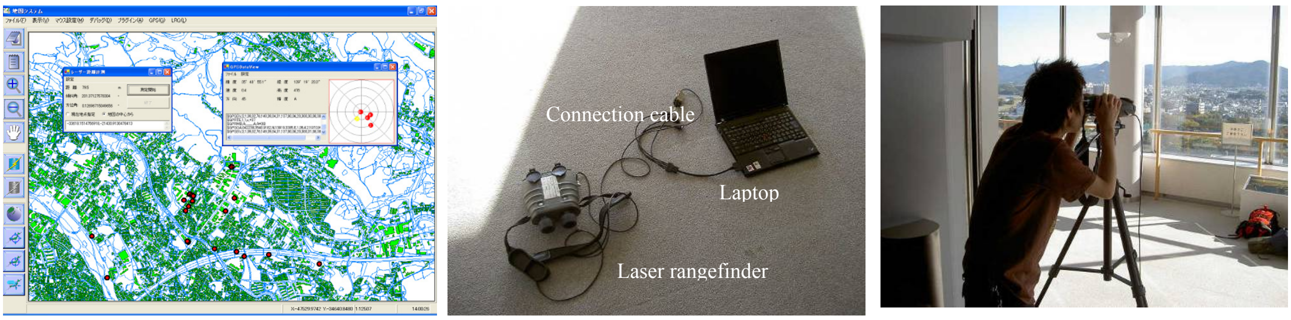

Figure 4 Laser rangefinder function
Left: Screen shot of the laser rangefinder function. Center: Example of the system configuration for the laser rangefinder function Right: Photograph of laser rangefinder in use.

2.4. The Information Sharing Function using an Ad hoc Network

We developed two additional functions to accomplish information sharing using ad hoc network technology, a schematic of which is shown in Figure 5. One is an information sharing function and the other is an information communication function. The information sharing function shares the task of information collection between the terminals of the investigators, and the communication function transmits information to a remote terminal by the bucket brigade method. By using these functions, information sharing and transmission between the terminals are made possible in the case of a communication blackout during a large-scale earthquake.

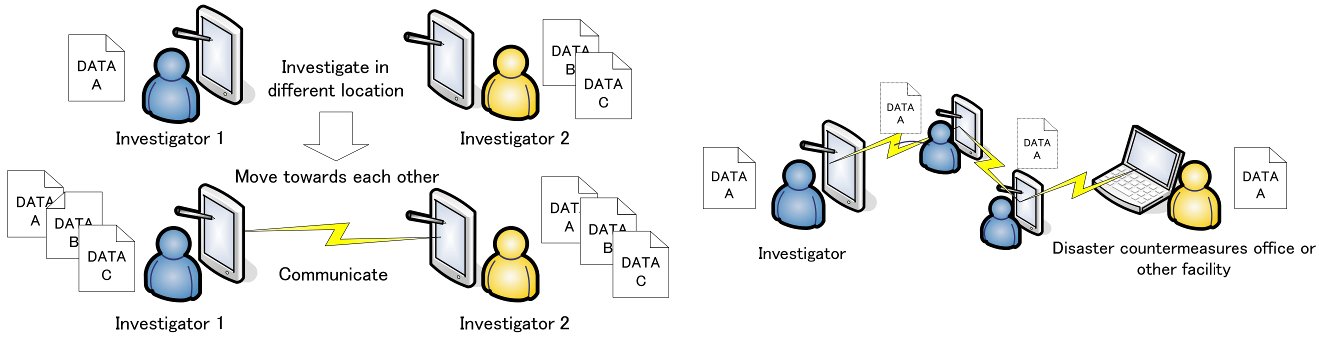

Figure 5 Information sharing and communication using ad hoc network.
Left: Information sharing function. Right: Information communication function.

2.5. Other Functions

2.5.1) The information sharing function using an RFID tag

As shown in Photo 3, we have developed an additional function that writes or reads assessment results to or from an RFID tag [6]. This function is intended to compare previously recorded building data with data on the current status in order to facilitate rapid damage assessment. The user inputs the grade of a building's incline and other data, and the application classifies the building into three risk categories: dangerous, requiring special attention, and safe. The assessment results are electronically deposited on-site for use by other rescue teams, thus avoiding duplicative investigation, streamlining relief subsidies, and contributing to the timely establishment of a detailed disaster database.
To use the system, investigators point to locations represented on the GIS screen and input information about collapsed buildings, fires, and road blockages at that location. The GIS displays the RFID reader-writer window on the screen, and the data from the GIS are transferred to RFID tags. The combined system can determine a worker's present position with the help of the connected GPS.

Photo 3 Intelligence sharing function with RFID tag.
Left: System equipment. Right: Equipment in use.

2.5.2 Cooperation with other systems' simulations

As shown in Figure 6, The DICSS can cooperate with other systems via the information sharing and integration platform [7], such as the fire spread prediction simulation [8] and the evacuation simulation [8]. The ability of DICSS to cooperate with these systems aids in decisions being made at disaster headquarters and helps ensure the safety of investigators.

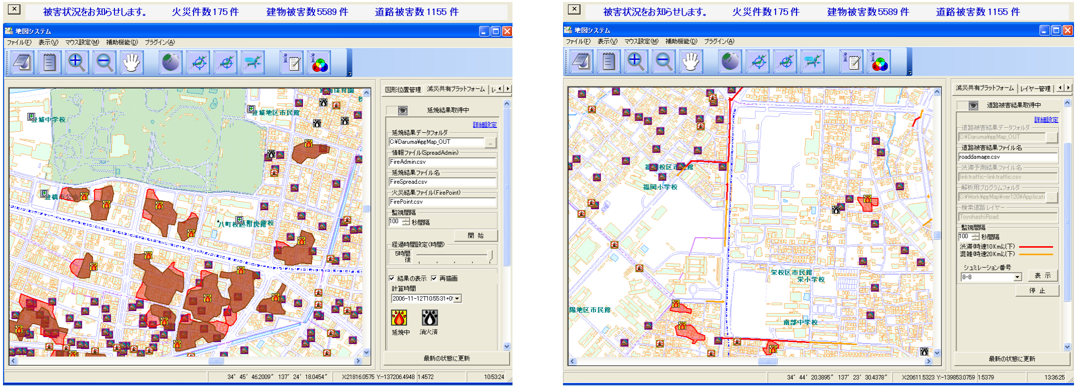

Figure 6 Cooperation with other systems' simulations.
Left: Fire spread prediction simulation. Right: Evacuation simulation.

3. EXPERIMENTS

We carried out several experiments to test the efficiency of the DICSS. In particular, we compared its advantages and disadvantages with those of the conventional method based on paper maps.

We carried out an experiment in Kamijujo, Tokyo (with an area of approximately 25 ha, a population of approximately 3,700, and approximately 1,500 houses) in 2005. During the experiment, images of collapsed buildings, fires, and road blocks were posted in different places in the experiment area. Four investigators carrying tablet PCs and wearable PCs with the DICSS system evaluated the extent of damage to buildings, damage due to fire, and damage to the road displayed in each poster. The investigators input their inspection results into their terminals. Photo 4 shows a poster of simulated building damage in one panel and data collection being performed by investigators in the others.

Photo 4 Left: Poster of simulated building damage. Center: Use of tablet PC. Right: Use of wearable PC.

Table 2 Experimental results

	Investigator	Fire	Building damage	Road block	Investigation time
Tablet PC	A	3/3	12/15	3/3	104 min
	B	3/3	13/15	3/3	124 min
Wearable PC	A	3/3	12/15	3/3	115 min
	B	3/3	14/15	3/3	109 min

* The number of investigated posters/ the number of the posters

Table 2 shows the results of the experiment. Although all investigators overlooked one poster each, those with wearable PCs (except for Investigator B) finished their investigations within two hours. This investigation time was approximately the same as that in the experiment conducted in the same area in 2004, wherein investigators used the conventional method based on paper maps but that otherwise had identical experimental parameters. In conclusion, the proposed system was found to be comparable with the conventional method regarding the required input time; however, the proposed system allows much more efficient data analysis because the data are digital as soon as they are input.

4. CONCLUDING REMARKS

We have proposed the Disaster Information Collection Support System (DICSS) to efficiently perform the collection, transmission, and consolidation of actual data pertaining to areas affected by a disaster utilizing ICT equipment. Additional functions to increase the efficiency of the investigation were also added to the system, such as an information sharing function using an ad hoc network, an information collecting function using a middle-distance laser rangefinder, an information sharing function using a RFID tag, and a simulation coordination function. We carried out several experiments and found that the proposed system was more effective than the conventional method based on paper maps.

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