DISASTER INFORMATION PROVIDING SYSTEM UTILIZING UBIQUITOUS SPATIAL INFORMATION PLATFORM TECHNOLOGY

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ABSTRACT:

In order to encounter earthquake disasters, the local governments have provided earthquake hazard maps to the citizens and have promoted seismic reinforcement for the buildings in Japan. It is difficult to gather post disaster information but to find the solutions for gathering post disaster information is essential. By comparing the satellite images, acquired before and after the occurrence of disasters, it is possible to extract the information of damage-hit areas. Currently, we are developing a system for acquiring disaster information, based on the ubiquitous spatial information platform technology. A ubiquitous spatial information platform is a common platform which enables a user to receive and utilize geographic information of "where you are" and/or "where you want to know at anytime". The most fundamental element for ubiquitous spatial information platform technology is the unique ubiquitous identification code (ucode) assigned to real-world objects in a format easily readable by computers. A demonstration of the experiment for developing the disaster information providing system was organized in Kashiwa city, Chiba, Japan. SAR imageries acquired by TerraSAR-X satellite were processed and subtraction analysis was conducted as an experiment for change detection and information distribution for the changed buildings. GIS data for the buildings was previously constructed in order to conduct collation between the change detected points and buildings. In a real disaster situation, the fusion of disaster information extracted from SAR imageries, GIS data of buildings, and ubiquitous solutions would be helpful information for local authorities to realize the scale of the disaster and review the action plan aimed at rehabilitation and reconstruction.

1. INTRODUCTION

1.1 Disaster prevention measures and application of remote sensing technology

Japan is one of the world's most earthquake-prone countries. Specifically, Japan has approximately 20 percent total of all earthquakes with the magnitude larger than 6.0 in the world. In order to encounter such earthquake disasters, Japanese local governments have provided earthquake hazard maps to the citizens, and promoted seismic reinforcement of buildings. However, it is difficult to gather post disaster information and therefore finding the solutions for gathering post disaster information is essential. By comparing the satellite images, which are acquired before and after the occurrence of disasters it is possible to extract the information of damage-hit areas although there are difficulties to prepare such information well in advance before the occurrence of a disaster (Shibayama et al., 2007, 2008).

1.2 Ubiquitous network technology

A ubiquitous spatial information platform is a common platform which enables a user to receive and utilize geospatial information of "where you are" and/or "where you want to know at anytime". By combining information obtained from different sensors and map data on a common platform, it is possible to observe human activities and resource flows, capture environmental change, acquire information of one's present location regardless whether the user may be indoors or outdoors and offer route guidance using both indoor and outdoor models. The most fundamental element for ubiquitous spatial information platform technology is the unique ubiquitous identification code (ucode) assigned to real-world objects in a format easily readable by computers. This technology enables computers to automatically recognize real-world objects for processing guided by an awareness of the context.
Currently, we are developing a system for acquiring disaster information based on remote sensing and ubiquitous technologies.

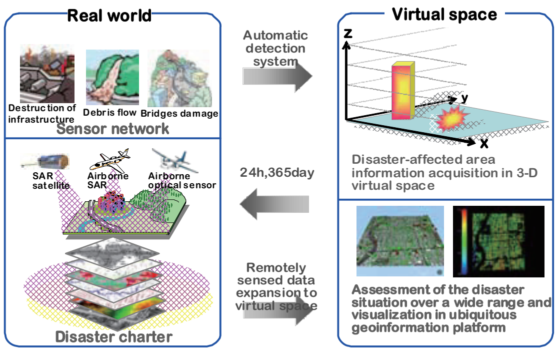

Figure 1. Conceptual diagram of disaster information gathering by remote sensing and ubiquitous technology

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2. SYSTEM OVERVIEW

2.1 Relationship with information providers

This system consists of multiple information providers and their connected relationships. Considering the disaster situation, the personnel in the anti-disaster headquarters office in a city asks the spatial information processing center and places the order to acquire the satellite images. Afterwards, an engineer in the spatial information processing center inputs disaster information to the system. In that case, the data including the buildings, the municipal districts and the city block, etc. in the ubiquitous spatial information platform are acquired from the two or more spatial information providers. The information, about the damage extracted from satellite images acquired before and after the disaster, is delivered to the anti-disaster headquarter in the city through the collation work. Figure 2 shows the connection among information providers.

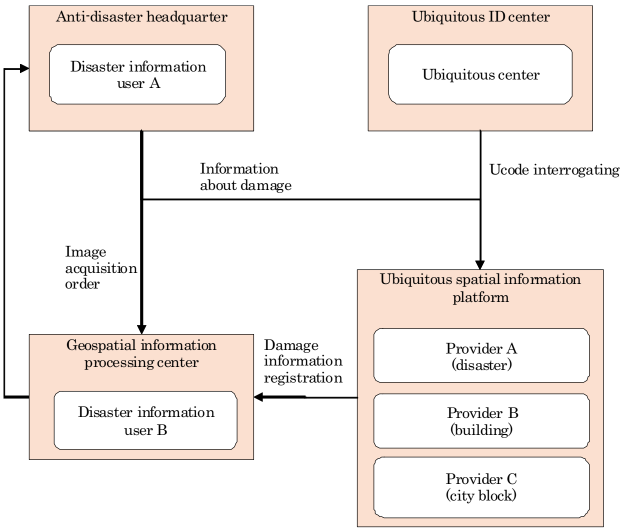

Figure 2. Connection of the information providers

2.2 Functions of the system

The functions of the system for disaster information gathering are described below. Satellite images and geospatial information are stored in the system during ordinary periods. In the disaster phase, followings steps as functionalities are performed for data processing:

1. Acquiring post disaster satellite images
2. Selection of satellite images acquired before the disaster
3. Extraction of changed area from satellite images acquired before and after the disaster
4. Conversion of the changed area to GIS data (polygons)
5. Registration to ubiquitous spatial information platform
6. Collation with the changed area and geo-spatial information such as buildings utilizing “ucode” as the keys
7. Listing the judged damaged buildings
8. Tallying of the number of damaged buildings by the unit of administration districts and/or the Japanese standard mesh
9. Displaying the results on the map

3. METHODOLOGY

The development of disaster information providing system as an experiment for the adopted methodology was demonstrated in the Kashiwa city, Chiba prefecture, Japan.

3.1 Utilized data

3.1.1 Satellite images

Two images of TerraSAR-X satellite were acquired for the present study (Figure 4). TerraSAR-X is an earth observation satellite with X-band Synthetic Aperture Radar (SAR). This satellite has an active phased array antenna system that is capable of providing up to 1m highest-resolution SAR imagery in SpotLight operational mode. EROS-B is a lightweight satellite, with a single electro optical camera system, acquires high-resolution panchromatic image data of 70cm ground spatial resolution. The satellite is designed to maximize operators’ flexibility in the creation and adaptation of the daily image acquisition plan. The flexibility is suitable for quick image acquisition in a situation of disaster. The study area in the optical image is shown in Figure 5.

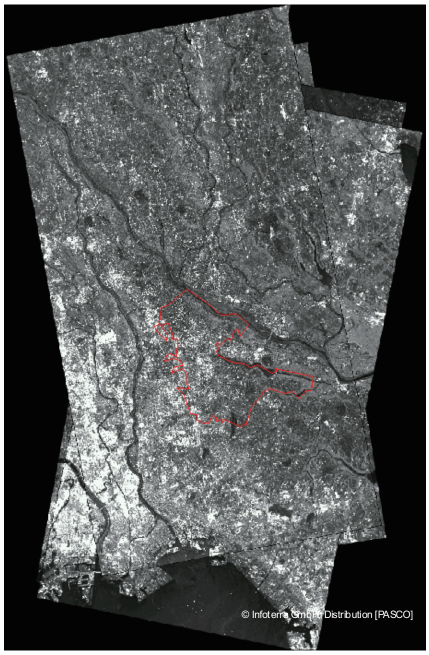

Figure 4. TerraSAR-X images

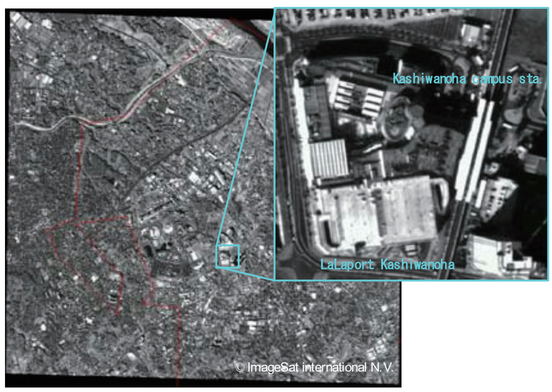

Figure 5. EROS-B images

3.1.2 Geospatial information

In the experimental procedure, geospatial information such as buildings, administration districts, the Japanese standard mesh etc. were prepared (Figure 6). These data can be also utilized for other business purposes, thereby providing is a great advantage of the ubiquitous spatial information platform technology.

Figure 6. Geospatial information around Kashiwa station

3.2 Experimental demonstration scenario

We examined and demonstrated "Kashiwa city inland earthquake" scenario. It was observed that occurrence of a powerful earthquake can cause extensive damages to the city. Figure 7 illustrates the experimental scenario for speedy information gathering after the earthquake.

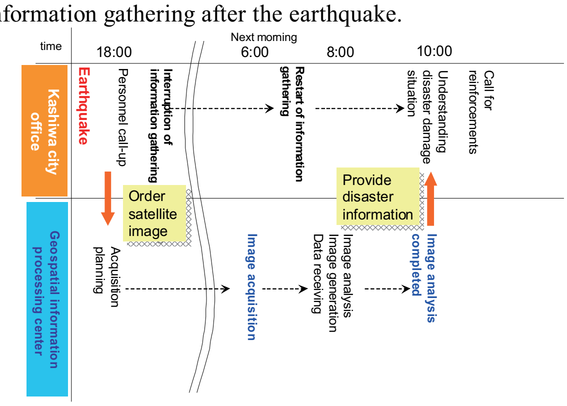

Figure 7. Experimental workflow scenario

3.3 Result of change detection and accuracy validation

Change detection accuracy was evaluated. The designated area for the evaluation was along Route 6 and LaLaport Kashiwanoha, a shopping mall in Kashiwa city (Figure 8). The area included 159 changed areas and 85% of the changed buildings were confirmed through ground surveys. This result indicated enough accuracy (Table 1) to provide damage information of the entire city immediately after the disaster as flash news.

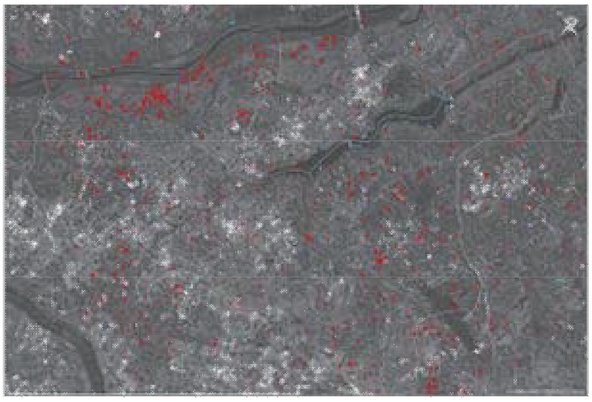

Figure 8. Changed areas over Kashiwa city

Item	Count
Recently changed building	87
Estimated changes in parking lot	22
Influence of civil engineering work	16
Seasonal changes	11
Other, Unknown	23
Total	159

Table 1. Validation for the change detection accuracy

3.4 Functional evaluation of the developing system

Changed areas extracted from multi-temporal SAR satellite images were fed into the system and displayed in red color on the map as shown in Figure 9. Buildings that overlap the changed areas can be detected by relating to ucode. Figure 10 depicts the estimated damaged buildings in yellow.

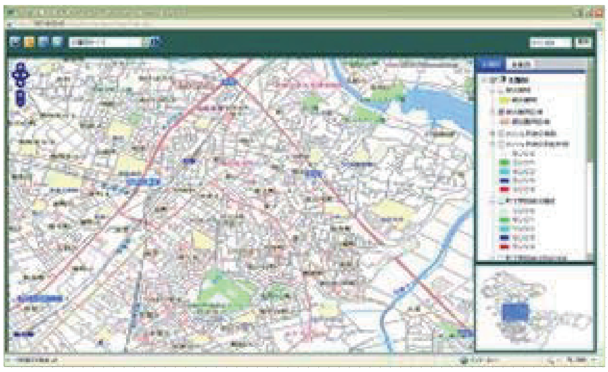

Figure 9. Change areas extracted from multi-temporal images

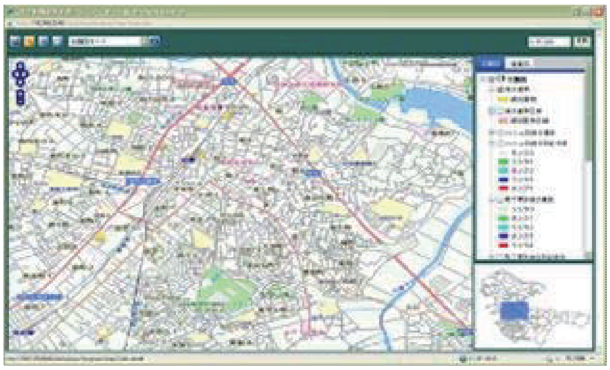

Figure 10. Estimated damaged buildings

The estimated damaged buildings can be output as a list with the address and the building name, etc. (Figure 11). This kind of damage information provision to the anti-disaster headquarters in the city will improve the efficiency of anti-disaster work such as relocation of the staffs.

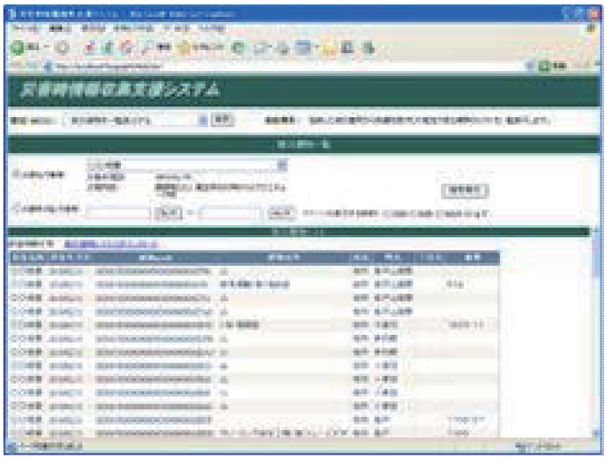

Figure 11. List of the damaged buildings

Also, tallying of the number of damaged buildings by the unit of administration districts and/or the Japanese standard mesh (3rd mesh) can be performed. The system has function to display maps to visualize entire damaged areas (Figure 12).

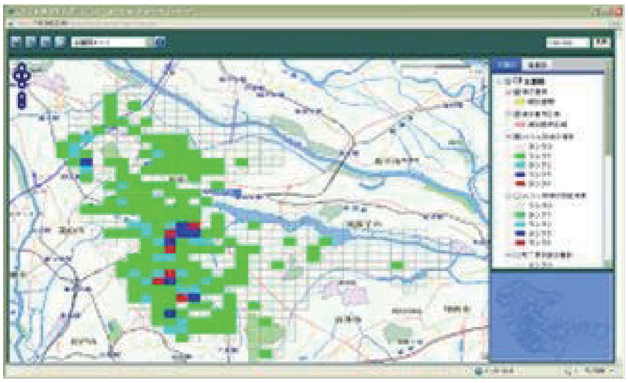

Figure 12. Visualization of extensive damaged area on the map

4. CONCLUSIONS

A disaster information providing system by utilizing ubiquitous spatial information platform technology and the results of the experimental demonstration are presented in this paper. As we are considering the system realization in Japan, there is a great possibility that the system will operate as an effective way to minimize the extent of damages caused by disaster. It is essential to monitor the land situation irrespective of any weather condition 24 hours a day, and every day. It is also necessary to establish a system utilizing spaceborne and airborne sensors, ground sensors and information communication technologies such as ubiquitous spatial information platform technology. Our ubiquitous based disaster information system is under satisfactory development stage and anticipated to be fully operational in 2011.

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