

DISASTER INFORMATION ACQUISITION SYSTEM USING MULTI-PLATFORM REMOTE SENSING TECHNOLOGY

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ABSTRACT:

Japan is one of the most earthquake-prone countries in the world and also faces frequent typhoons, severe rain storms and sediment-related disasters. Despite those frequent natural disasters, it is difficult to determine the extent of the disaster damage rapidly and extensively. Considering such problems, it was greatly realized to develop highly effective usages of spaceborne and airborne sensing technology. Currently, we are developing a disaster information service based on satellite and airborne sensors. In the proposed system, Synthetic Aperture Radar (SAR) satellite sensor acquires images of the areas of interest during normal phase, and archived as ready-to-use reference data. After the occurrence of a disaster the quickest way of data acquisition is possible by utilizing satellite or airplane sensors. In case of SAR satellite, it is possible to extract changed areas between images acquired before and after the disaster. If more detailed information is required, images acquired by airborne sensors are analyzed for mapping disaster-affected areas and can be provided to the decision makers. Moreover, acquiring images regularly after disaster, it is possible to monitor recovery and restoration status of the damaged areas.

1. INTRODUCTION

Japan, where about 10 percent of all volcanoes in the world are located, is one of the most earthquake-prone countries in the world and also faces frequent typhoons, severe rain storms and sediment-related disasters. Despite those natural disasters, it is difficult to determine the extent of the damage extensively caused by disaster in a shortest possible time. There are some ongoing operations to utilize satellite resources to provide data such as, the International Charter 'Space and Major Disasters' (Bessis, et al., 2004) and Sentinel Asia project (JAXA, 2007), however, information from satellite data is limited. Realizing these limitations, it is necessary to make the most effective use of spaceborne and airborne remote sensing technology for gathering the disaster information. To compare the satellite images, acquired before and right after the disaster, it is possible to retrieve the information of damage-hit areas, but difficult to prepare such information well in advance before the occurrence of the disaster. Currently, we are developing a system for acquiring disaster information based on spaceborne and airborne sensors. Remotely sensed images provide very helpful information during disaster if they are also utilized in normal phase. Also, integrating various kinds of images can assist analyzing the situation in terms of when (past, present, or future), where, and how. Figure 1 depicts a scheme to assess the situation correctly and to conduct future predictions.

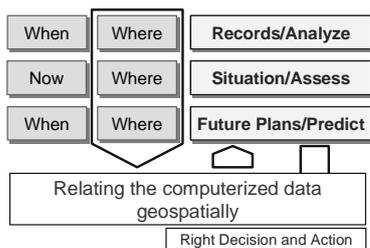


Figure 1 Importance of geospatial information

2. CONCEPT AND METHODOLOGY

2.1 Concept

It is crucial to acquire satellite images at different phases of disaster occurrence: namely, pre-disaster phase, disaster phase, and recovery phase. Assuming that image data can be acquired with various sensors during disaster, methodology to integrate those images with periodically acquired images are discussed in this article. Eventually, it is ideal that people can access and effectively use the information.

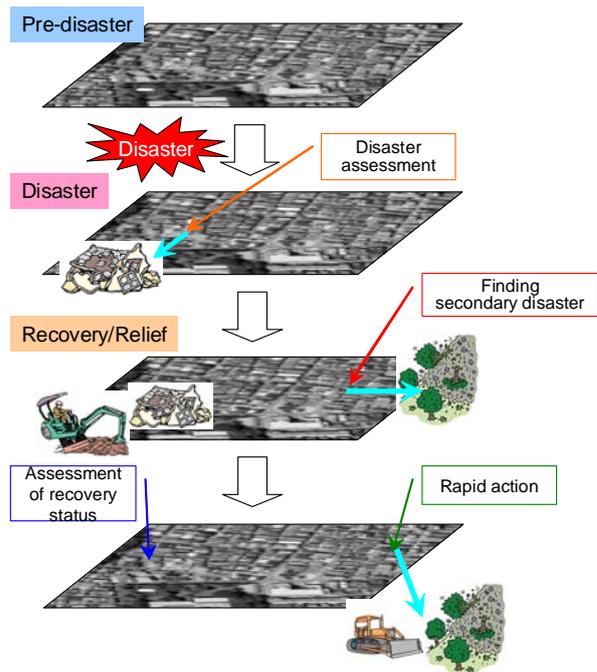


Figure 2 Provision of disaster information

Once a disaster happens, location data obtained by various kinds of sensors on the ground of the real world is reported automatically to virtual space and then the data acquisition by multi-sensor and multi-platform such as airborne sensors and satellite sensors is carried out urgently. Subsequently, the data is expanded to virtual space again and detailed disaster information is produced and visualized in the virtual space.

2.2 Pre-disaster phase

In the current proposed system, Synthetic Aperture Radar (SAR) satellite sensor acquires images of the areas of interest during pre-disaster phase, and archived as ready-to-use reference data. Also, image acquisition by optical sensors is necessary as a reference image. Bringing this system to realization, a database that includes satellite images and various kinds of geospatial information can be developed.

On the other hand, the combination of periodically acquired images is useful as basic data for making hazard maps and conducting an evacuation drill for the countermeasures against disasters. This also can be utilized for the maintenance of public infrastructure, roads, rivers, forests etc.

2.3 Disaster phase

During the occurrence of disaster, information is to be retrieved based on the following procedures:

- (a) Grasping the situation of the damage-hit areas with helicopter TV system and Closed-circuit Television (CCTV).
 - CCTV is set to monitor pre-disaster situation and record movies of the site on regular basis.
 - Acquiring the disaster information from websites of governmental organization and news reports from other media agencies.
 - Specifying where the disaster occurs and consequently placing order for image acquisition of the disaster area by the SAR satellite (e.g., TerraSAR-X).
- (b) Assessing the disaster area extensively with SAR satellite images.
 - Using TerraSAR-X, advantages of high spatial resolution and shorter revisit time.
 - Maximum spatial resolution of the TerraSAR-X image is 1 m.
 - StripMap mode is capable of acquiring an image of large area (30 km x 50 km at 3 m ground spatial resolution).
 - Although the revisit of TerraSAR-X is 11 days, it is possible to cover a certain location in Japan within 3 days at 80% of success rate.
- (c) Comprehending the area of disaster and the level of the damage by analysis of SAR images.
 - Interpreting the acquired SAR image and comparing images before and after the disaster, one can know the center and the extent of disaster.
 - Consequent of this method, we can specify where we have to retrieve detailed information. Aerial photos from can be specified more.
- (d) Acquiring images of severely damaged areas with airborne optical sensor intensively.
 - Acquiring images of areas specified by SAR image analysis intensively.
- (e) Pinpointing the location of disaster sites by analysis and image interpretation of the optical images and creating disaster maps.

- With the result of analysis of the SAR satellite image and interpretation of the aerial photos, delineation of the areas of disaster on the map can be prepared in advance.
- Depending on the level of necessity, field work can be conducted if possible to verify the accuracy of analysis.

When a disaster happens, the quickest way of data acquisition can be conducted from satellite or airplane. In case of SAR satellite, it is possible to extract the areas of changes between images acquired before and after the disaster.

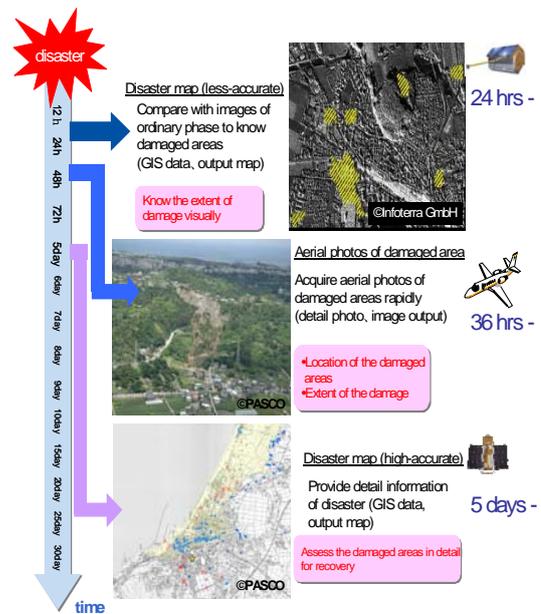


Figure 3 Data acquisition procedure

3. RESULTS AND DISCUSSIONS

3.1 Earthquake

We conducted a simulation of the workflow as described above taking the Chuetsu-oki earthquake in Niigata, Japan on July 16th, 2007 as a case study. When the earthquake occurred, the weather condition was bad due to presence of clouds, and aerial photo acquisition of the earthquake site could not be done until 2 days after the disaster. On the other hand, checking the orbital path of TerraSAR-X at that time, we assumed that image acquisition could have been done about 30 hours after the earthquake. If image analysis had been done a few hours after that the occurrence of the disaster, aerial photo acquisitions would have been planned more effectively. As a result, the extent of the earthquake damage could have been determined more rapidly so that it would greatly assist relief and rescue activities after the disaster.

If more detailed information is demanded, images acquired by airborne sensors can be analyzed for mapping disaster-affected areas and can be provided to the decision makers. Moreover, acquiring images regularly after the disaster, it is possible to monitor recovery and restoration status of the damaged areas.

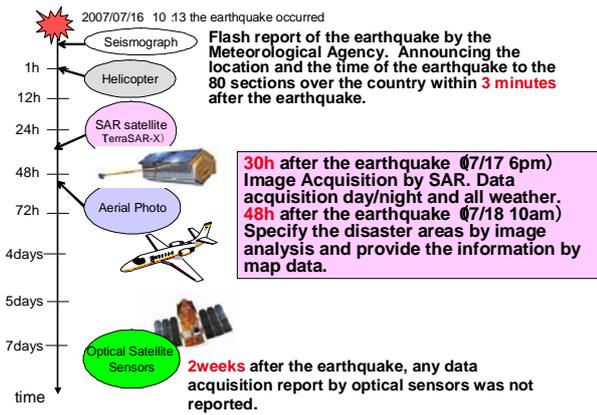


Figure 4 Time distance of providing disaster information

3.2 Flood

We also studied the capability of waterbody extraction during flood disaster using SAR images. However, there was no actual flood, we applied the method for using the backscatter intensity difference between two temporal TerraSAR-X images to extract the waterbody of paddy fields. The study area is Tanegashima which is located in the south-western part of Japan. Two TerraSAR-X images were obtained at the beginning and late February, 2008 and assumed as pre-disaster and post-disaster images, respectively. In this area, rice field irrigation is practiced during that period so we expected that paddy fields which have been irrigated could be extracted by comparing the temporal images. The two images of Tanegashima were acquired at the same acquisition parameters such as the same orbit (descending) and same incidence angle (Figure 5).

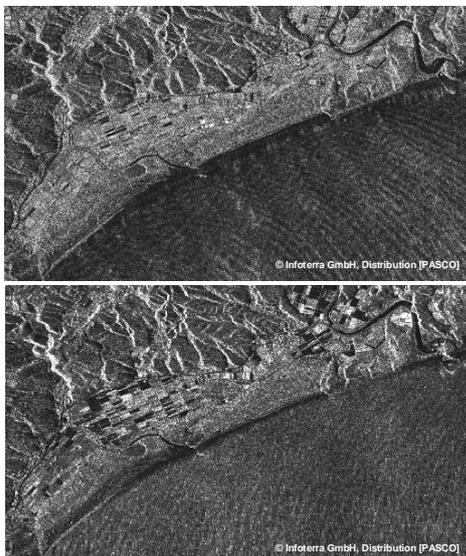


Figure 5 TerraSAR-X images (Tanegashima)

Figure 6 shows the colour composite image of 3 February image with red and 25 February with cyan. Paddy fields which seem to have been already irrigated at the time of first acquisition (3 February) and channels can be seen as black due to specular reflection on its water surface. Red area indicates paddy fields which seem to be irrigated by the time of second image acquisition (25 February). Field investigations have confirmed that those paddy fields were irrigated at the data

acquisition date. In addition, these paddy fields were 20m x 50m of rectangular shape and area of 1,000m² by farmland consolidation.

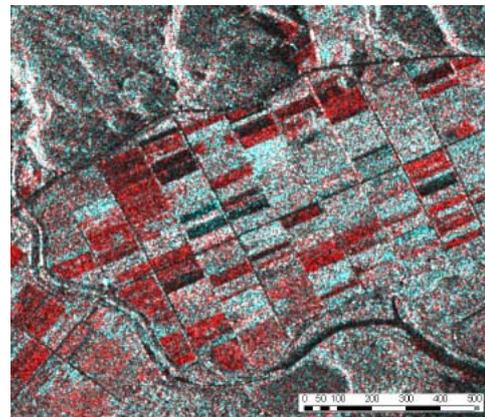


Figure 6 A color composite image of Tanegashima

4. CONCLUSIONS

A methodology was introduced to assess the situation of disaster rapidly and effectively utilizing data acquired by various sensors. In the present study we utilized TerraSAR-X satellite but this system has scope to integrate the information on disaster from other sensors also. To bring such a system into the operation in an actual situation of a disaster, it is necessary to construct the database based on a wide range of geospatial information ready to be used as reference data. One of the important issues is to rapidly transmit the information acquired from various sensors to the decision makers.

Currently, considering the system realization in Japan, and if the issues discussed above are solved, there is a great possibility that the system operates as an effective way to minimize the extent of damage 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 to utilize satellite borne and airborne sensors, ground sensors and communication technologies.

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