

Virtual Chi-Chi City on Digital Earth Model as Post-Earthquake Recovery Digital Archive

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ABSTRACT

Historical evidences reveal that disasters bring about changes in the damaged cities across the world through the recovery processes. Recent geoinformatic technologies enable us to create a virtual representation of a city on a digital model of Earth such as GoogleEarth; these representations can demonstrate the post-disaster recovery processes. The authors have tracked the post-earthquake recovery process of the Chi-Chi Township damaged during the 1999 Chi-Chi earthquake in Taiwan and constructed a virtual representation of the city based on field surveys to present its reconstruction conditions as of 2006. The objective of this study is to report how to construct a representation of a city in cyber space and to discuss the significance of recording the recovery process on a digital model of Earth.

This study first describes the background information regarding the experiment of the trial from the viewpoints of historical changes in the recording media and the significance of the disasters occurring in a city as critical points in its long-term urban development. It then outlines the six procedures adopted to create a digitalized virtual representation of the Chi-Chi Township in addition to the previous researches conducted by the authors. In the third part, the following procedures are explained in detail: (1) creating a base map using the information obtained from a previous research conducted by the authors; (2) conducting a field survey to obtain detailed photographs of building elevation and the number of stories of the objectives; (3) image processing in order to transform the captured photographs as rectangular polygons in cyber space; (4) drawing building outlines using Google Sketch Up, a three-dimensional modeling software; (5) applying the processed images as texture and painting roofs, and (6) Inserting the information related to the reconstruction process. Finally, this study discusses the usage of the abovementioned model to understand the post-disaster recovery processes and suggests the possibility of using a digitalized virtual representation of a city on a digital model of Earth as one of the methods to realize digital archives in the era of the geoinformatics.

Keywords: 1999 Chi-Chi earthquake, Chi-Chi, post-earthquake recovery, digital city, digital archives, GoogleEarth

1. INTRODUCTION

1.1 Present circumstances of spatial information science

The field of spatial information is changing dramatically with the development in remote sensing technology. In the November 2004 issue of *Nature*, Gewin (2004) stated that geotechnology and nanotechnology would be two of the biggest business fields, the third being biotechnology, in the twenty-first century. The technological innovation in the field of spatial information mentioned in this study is forecast to change urban spaces drastically. In addition, spatial information technology can prove to be an important tool to record recovery processes.

1.2 Digital archive for urban spaces

For a long time, cities have been formed as a result of the various changes in their environments. Historical evidence reveals that disasters are likely to dramatically influence the transformation of cities. For instance, Chicago has been transformed into a city bristling with skyscrapers since the conflagration in 1871. San Francisco had also attempted to achieve new urban development after the occurrence of the earthquake in 1906 by implementing the “Phoenix plan.” Thus, based on historical evidence, we can conclude that disasters and reconstructions tend to be the crucial steps in influencing dramatic transformations in cities. In a previous study, the authors reported on recording disasters and reconstructions and examined a methodology to realize the same (Murao, 2006a). From the viewpoint of geotechnological and archival science, it is important to record the process of changes in a city by focusing on the most crucial moments during historical disasters and subsequent reconstructions on a virtual representation of the city on a digitalized model of the Earth. The authors have created a networked virtual representation of the Chi-Chi Township, Taiwan, which was struck by the 1999 Chi-Chi Earthquake, in order to record the reconstruction conditions on a three-dimensional representation of the city on a digitalized model of Earth accessible freely through GoogleEarth.

2. CONSTRUCTION OF DIGITAL CHI-CHI TOWNSHIP

2.1 Creating a base map

The digitalized data created by Murao et al. (2004) using GIS was applied as the base map in order to construct a virtual city. Prior to this, the authors conducted a field design survey based on the IKONOS satellite images and attempted to define the actual outlines of the buildings (Murao, 2006b). The number of buildings in the target district exceeded 2,000. Then, the data of the shapes of the buildings obtained in this research was digitalized on GIS and the base map was applied to it. Further, the target district was divided into 86 town blocks for further analysis.

2.2 Photographing the building façade

By using the base map created in 2.1, the façades of the buildings in the Chi-Chi Township were photographed in August 2006. Four volunteers photographed the façades of approximately 1,500 buildings. The following rules were set to ensure that every photograph captured by the volunteers would be of the same quality.

Rules for photographing the building facade

- a. Set the resolution of the camera to 640×480 pixels
- b. Photograph block by block
- c. Photograph the buildings in a town block in a counterclockwise order as shown in Fig. 1 (a) to enable computers to retouch the images
- d. Photograph one building per shot and, if possible, along the line of sight perpendicular to the face of the building.
- e. If the entire façade of a building cannot be captured in a single scene, photograph it by dividing the scenery into several.
- f. Conduct the division from the lower to the upper part and from the left to the right side in the above case

Further, the volunteers recorded the form of each roof and the story of each building while photographing it (Fig. 1(b)).

2.3. Retouching the photographs

The 1,500 digitalized images photographed in process 2.2 were classified according to their block and road. In other words, different directories were created for each block and the images

photographed in each direction across the roads facing the blocks were stored in folders in these directories. Even the buildings facing the narrow roads in the blocks were photographed and classified. These images would be applied as textures on the façade of the virtual representation of the buildings in the three-dimensional model of the city. However, the images were photographed at the ground level at the site and not along the line of sight perpendicular to the face of the building. Therefore, the images were processed by using Adobe Photoshop in order to correct these differences. After retouching each building image, an elevation image of the cluster of the buildings as seen from a road was produced in order to easily apply it to the digitalized façade. This elevation image is shown in Fig. 2.

2.4 Creating three-dimensional space using Google Sketch Up

Next step is to create an outline of the Chi-Chi Township on a computer. However, in order to lay the created three-dimensional space on GoogleEarth, the following steps were necessary: First, the coordinates of the base map were positioned on GoogleEarth. Second, the outlines of the buildings on the three-dimensional space by using Google Sketch Up, which is one of the applications of GoogleEarth. The stories of the buildings and the forms of the roofs were adjusted based on the information and photographs obtained at the site. Further, the vertical positions of the buildings were adjusted according to the elevations on GoogleEarth. With the completion of these steps, the scenery of the target district with the building outlines was finally generated.

2.5. Applying the texture

The last step in creating the three-dimensional space was to apply the photographs of the building elevations processed in 2.3 as textures to the frames created in process 2.4 (Fig. 3). Because it was difficult to photograph the roofs, the digitalized representations were painted in the three-dimensional space by referring to the photographs instead of applying them as textures.

2.6 Inserting the information related to the reconstruction process

The information regarding the reconstruction process was inserted into the virtual representation of the city created in this study by using the placemark function of GoogleEarth. This information was obtained from the authors' previous research (e.g., Murao, 2006b) and can be displayed on GoogleEarth as described in Table 1.

3. CHI-CHI CITY ON DIGITAL EARTH

This three-dimensional representation of the Chi-Chi Township was referred to as "Digital Chi-Chi City." The virtual model of the city in cyber space represents the Chi-Chi Township as of August 2006. Fig. 4 shows the constructed digital Chi-Chi Township.

By only uploading the data constructed in this process, it enables every visitor to enter the Chi-Chi Township freely, gain an experience similar to that of an actual visit through GoogleEarth, and read the information regarding the reconstruction process obtained and processed during the authors' previous researches. Information regarding the reconstruction of the important facilities in the target district is made available to the visitors by using the placemark function, as shown in Fig. 5. As research regarding the reconstruction process progresses, new information will be updated when appropriate and the range of the contents can be expanded.

5. CONCLUSION

In this study, the authors report on the Digital Chi-Chi City constructed to record the reconstruction conditions of the damaged area and allow visitors to freely access a three-dimensional representation of the city on a digital model of Earth. In order to construct the Digital Chi-Chi City, the following processes were undertaken:

1. Creating a base map
2. Photographing the building façade
3. Processing the photographs
4. Creating a three-dimensional space using Google Sketch Up
5. Applying textures
6. Inserting the information regarding the reconstruction process

This Digital Chi-Chi City enables visitors from around the world to freely access the city on a digital model of Earth and gain an experience similar to that of actually visiting the Chi-Chi Township.

The characteristics and significance of the Digital Chi-Chi City are as follows;

1. It is a three-dimensional representation of actual city on a digital model of Earth created using the freely accessible platform of GoogleEarth
2. For a city with a long history, the process of reconstruction following a disaster brings about dramatic changes in the city and becomes a crucial point in its history. The digital Chi-Chi City is a reproduction of the actual city in three-dimensional space for this geoinformatics era.
3. The procedure for inserting the conditions of the recovery process into the representation in the digital model of Earth exemplifies one of the possibilities wherein digital archives can be used to record reconstruction processes.

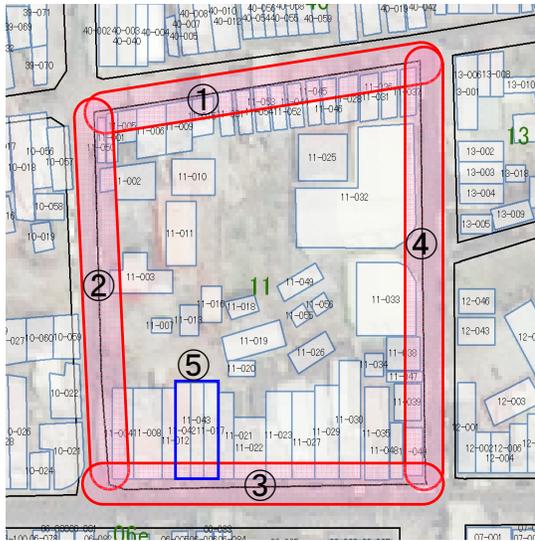
The authors will update the information regarding the reconstruction process when appropriate while continuing their research on the Chi-Chi Township.

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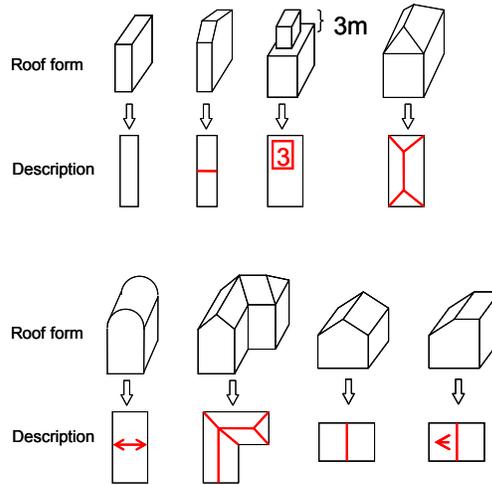
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(a) counterclockwise order to photograph

How to record the roof form in Chi-Chi



(b) recording roof form

Fig. 1 Precautions to be followed while photographing the building façades



Fig. 2. Elevation image of the cluster of the buildings as seen from a road

Table 1 Example of the information regarding to the reconstruction processes that can be displayed on GoogleEarth

| Contents | Information Classification |
|--|----------------------------|
| Location of the facilities | description by Placemark |
| Explanation of the facilities | text |
| Image of the reconstruction process | image |
| Result of the analysis of the reconstruction process | graph, table, data, etc. |



Fig. 3 Application of the elevation photographs as textures to the building frames



Fig. 4 Overview of the Digital Chi-Chi City



Fig. 5 Example of displaying the information regarding the reconstruction process using the placemark function