# AN APPLICATION OF VIRTUAL REALITY FORMATS IN MANAGING VISUAL INFORMATION OF EARTHQUAKE DAMAGED SITES

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ABSTRACT: The purpose of this paper is to present an application of virtual reality (VR) formats in environmental information management which could have facilitated the retrieval and illustration of damaged site information during Taiwan 921 earthquake. Disadvantages in data collection are listed. The comparison of data types lead to the demand for the collection of site-related data. This research strongly suggests that environmental data should be collected in a VR formats before earthquake occurred. Photos should be taken, transferred into VR panorama and object formats, stored in a server, and used to serve emergency rescue needs.

Keywords: 921 earthquake, virtual reality, visualization

## 1 INTRODUCTION

The purpose of this paper is to present an application of virtual reality (VR) formats in environmental information management which could have facilitated the retrieval and illustration of damaged site information during Taiwan 921 earthquake. This study applied image-based VR technology to manage earthquake data under the format of panorama scenes and objects. Scene format is made by stitching 360 degrees of digit photos at a location. Object format is made by assembling 360 degrees of building images retrieved from public media like WWW news pages. Both formats can be viewed in a virtual environment through a browser.

*Disadvantages in data collection*

In the earthquake, existing digital and newly recorded data showed several disadvantages:

1. Fragmental data collection: Many photos and videos were taken for analysis and future planning purposes. These visual data appeared to be fragmental in presenting the occurrences of damaged sites. Audiences could only access the information from limited scope of view. It would be difficult to read or to inspect other damaged parts of the same site right after the earthquake.
2. Redundant data recording: Many photos were taken by journalists from the same viewpoints because damaged sites, which held restriction to unrelated pedestrians and vehicles, were only visually accessible from distant locations. The redundant and limited data recording showed the two sides of the same problem in visual data collection.

*Comparison of data types*

3D urban models have been built-up in different regions of Taiwan through the effort of governments and academics [1-3]. In the cities like Taipei and Tainan, models have been used in urban design evaluation. Related studies also showed the application of different detail levels in environmental evaluation [4-6]. Although 3D digit urban models have become more important in evaluation and it's also easier to add new buildings to model database later, the use of it still depends on the execution of program and rendering of images in order to inspect contents. The display of model contents also relies on additional program to increase speed. If browser is applied for VR data after format transfer like VRML, the number of polygons have to be reduced for better display speed too. Data translation usually loses certain attributes. Decision has to be made based on the trade-off between the friendly user interface and the completeness of display data.

Urban images feature differently in the morning, afternoon, and evening. Changes are also made by new construction or renovation of buildings. The changes usually are not shown in the database immediately. What is displayed is filtered or simplified data in a concise form. For example, 3D models usually use aerial photos and maps to define the footage of building blocks to fill the gap of ambiguity in dimension estimation. Even the building height is estimated by multiplying story number by estimated height which is usually 3 meter. As we usually know, difference may exist between the design of a building and its surroundings now and years after. Although urban simulation works for different emphasis, the precision of models does not fully meet the requirement in reflecting current status.

Unfortunately existing digital site information was obsolete. The existing site information could be useful for rescue teams to gain control sooner. The information is also useful for referencing in future demolition and reconstruction tasks, because urban model can provide architectural designers with more detailed site data. Although traffic routes and human resources were well-documented in GIS databases, visual information which could be more helpful to gain direct control of sites was missing. Additionally, it seemed most of the existing site-related information did not contain panorama-like images to initialize and to promote people's immediate comprehension. This type of images either seldom existed or was collected in a fragmental manner that could hardly provide any assistance during the earthquake.

In addition to being prepared with routes to earthquake sites, rescue team needs to be briefed of the site as much as possible. Again, 3D models present less visual information than image-based scenes under the consideration of data completeness and immediate availability. In contrast, 360 degree panorama scene can be easily comprehended by rescue members and gain more control of site.

## 2 DEMAND FOR THE COLLECTION OF SITE-RELATED DATA

Take 921earthquake for example, people kept reading news from different media sources. Most of the media only reported single frame photos or video clips of collapsed buildings. Most of the news featured focused report and left neighboring information untouched. The neighboring information around a collapsed building is the same important as the information of the building, because the rescue team or control center can use it to gain more control of the site like the status of a street or a cross road to check if it's clear or blocked. The site information can accelerate rescue process by guiding the route of ambulances or prevent unneeded interruption from crowds by deploying policemen on site. Discrete video cameras can only be deployed by facing different directions, instead of 360 degree of the site. One 360 panorama video camera can substitute many traditional monitoring cameras[7]. Another disadvantage of the fix direction cameras is that it might leave out the records of some important views at certain angles for the post occurrence analysis.

Demand for the collection of site-related data at least should meet following requirements:

1. Comprehension of design and environment: Architectural practice usually applies simulation technologies to enhance the comprehension of design and environment [8,9]. The application of virtual reality (VR) has appeared in many fields to facilitate the manipulation of artifacts especially with immersive reality [10,11]. In the presentation of sites that encountered earthquakes, the VR technologies can be helpful to record site data before or after the occurrence. One of the VR types applied in presenting detailed visual information is an image-based VR which stitches images 360 degree around a view point to create a panorama-like scene.

   Complete and integrated environmental information is fundamental in fulfilling immediate rescue requirement. The VR scenes and objects, which appear to be very useful, have to be prepared and ready before being applied. One of the most useful devices is panorama camera that can take 360 degree of view and transfer video data to a remote site like rescue center to help the control of site.
2. Information infra-structure: In order to study the causes of damages made to various sites in Taiwan, surveys have made intensively either in a numeric or visual forms. As the focus of this study, the images collected from damaged sites are important sources in post earthquake analysis. The data collected in damaged sites include types like images and videos in a single or sequence frames. The data need to be stored in a information infra-structure that will facilitates the pre-processing, presentation, and management of the images or multi-media data. This paper presents a 3D visual environment as the solution toward the manipulation of VR panorama, for the purpose of increasing the interaction between geometries and 2D drawings. The presentation of data can be made by browsers.
3. Chronicle information recording: A complete record of earthquake data should include the information before, in the middle, and after the occurrence. Although the time and type of natural disaster can hardly be predicted ahead, one important task that can be made beforehand is to establish basic environmental data to enhance the comprehension, to facilitate future resource management, and to reduce rescue efforts. Currently available aerial photos show a broad urbanscape but only limited detail information is provided. The 3D urban models that are used for the evaluation of deigned buildings and urban spaces, but only newly added buildings have enough details to facilitate evaluation. Simplified 3D models do not necessarily provide researchers or residents with scenes that are familiar in appearance and visual

experience. When earthquake occurs, site will be occupied by fires, demolished buildings, and chaos. Unless monitoring devices are still under operation and free of damage, hardly can any record be saved. Example can be seen from Ton-Shing building, which was collapsed in 921 earthquake [12]. The diagnose of structure failure could only be made from the configuration of demolished building parts, instead of building's collapse sequence. Arguments occurred for the lack of evidence in the mean time.

4. Information of surroundings: The record of earthquake damages should cover the surroundings of sites for the purpose of rescue and future analysis. Comparing site situations before and after earthquake would be useful in evaluation causes. Table 1 shows the differences of available environmental data between damaged and safe sites. Most of the existing data can be missing and irretrievable even after the rescue process.

Table 1. The difference available environmental data between damaged and safe sites

| | original environmental data | Environmental data after earthquake |
|---|---|---|
| damaged sites | fragmental, irretrievable | known, retrievable |
| safe sites | known, retrievable | unknown, simulation |

Figure 1. Expanded panoramas

Figure 2. A VR object and its images [14]

## 3 THE PHOTO RETRIEVALS IN THE CONSTRUCTION OF VR SCENES AND OBJECTS

In the preliminary test, panorama scenes and VR objects are created. The scenes are made of photos taken beforehand. Panorama images can be captured and created by in three methods with different resolution and precision. The first method is made by locating the photographer at the center and rotating 360 degree (see Fig. 1). It would be difficult to keep the pictures at the same level. However, this may reflect real situation during natural disaster when keeping a perfect position is difficult particular in a short period of time. The second method used a tripod to level pictures and to control the angles of each turn. This method can lead to a smoother transition between two pictures. The last method applied a reflective device attached to a camera lens to capture a whole panorama picture in one shoot. The procedure of stitching pictures is eliminated and is replaced by de-warping the donut shape into a landscape shape. An improvement to the third method is to capture a continuous video clip through a camcorder

The VR objects, that allows viewers to rotate 360 degree simply with the manipulation of a mouse, can also provide more information of a building from all angles. All the data in the study mainly come from network news report starting from the immediate broadcast on Sept. 21, 1999. The direct report of occurrence on site became very useful. However news photos showed that most pictures were blocked by barrier setup from traffic and rescue control. The barriers narrowed shots from few angles. Among the pictures, the report in Taipei appeared to be the most complete. All the pictures taken about the Ton-Shing Building can be categorized into two eye levels with 6 on top and 7 in bottom (see Fig. 2). Redundancy remains between and within photos that were taken in the daytime and in the evening. Since media kept reporting the rescue process of this building, the changes of appearance can be traced for future analysis.

The photos retrieved from WWW featured different sizes, resolutions, and viewing angles. All the pictures have to be centered and framed with the same resolution and size in order to compose a VR object. The adjust process is time- and effort-consuming. Some photos lose their resolution after this adjust. The VR object also contains one picture taken at night in order to be completed. The exemplify the difference may exist between Ton-Shing building and a well-documented VR object, this study took 12 pictures at two levels of height for the campus administration building which is clear from all angles (see Fig. 3). One of the altitudes is eye level and the other is located at eighth story of buildings nearby. The difference is obvious even three facades of the Ton-Shing building are surrounded by streets.

Figure 3. VR object and images of the administrative building

This research applied Reality Studio [13] to compose VR scenes and objects on a PC platform. Final result can be viewed from a browser with plug-in added. Six scenes were built around the site. The pictures were taken after the Ton-Sing Building was demolished. In order to simulate the earthquake scene, a previous made VR object was inserted into the place where the building was located. So a viewer will see the building object in the panorama scene where facing it. When browse mode is activated, a viewer can drag the mouse to the left or right horizontally in order to expand the view. A scene is usually connected to another through the previously defined region for a viewer to click on the change of mouse shape. While the building object is shown during the traversal of scenes, the mouse can drag to rotate it for different viewing angles. A higher visual level of height appears when the mouse is dragged upward. Although viewing different angles at the same location is not a familiar visual experience, this type of browsing displays visual information in a concise manner.

In order to facilitate the rescue tasks after earthquake, the urban-related information is introduced by:

- Departments: like police and fire departments or hospitals nearby. Information like address, phone number, and distance to the site is also provided.
- Buildings: In order to access buildings with more information, specific information like name, address, floor plans, usage, structure systems, or designer/design firm is provided if available.
- Streets: name, width, one–way or two-way
- Notes: other information that is important or is site-specific.

The site-related information is marked on panoramas by types of icons that can be linked to another windows showing detail data by clicking them (see Fig. 4).

## 4 CONCLUSION

This research strongly suggests that environmental data should be collected in a VR formats before earthquake occurred. A VR object requires many photos to complete a seamless assembly. A case study showed that there was insufficient data to create a complete object because only limited viewing angles of photos were available. Even after a number of media was searched, only several redundant pictures were found. It seemed more pictures could be collected in Taipei than the sites located in distant counties at central regions. The scene records not only can be used to compare the damage situations with the site before earthquake, but also help rescue teams gain better control of site from all viewing directions. With a collaborative operation and a possible joint assistance between academics and journalists, photos can be taken, transferred into VR panorama and object formats, stored in a server, and used to serve emergency rescue needs.

Future study of this research will include the buildup of 360 panorama VR scene database of whole city. To enhance the comprehension of earthquake site, 360 degree panorama VR scenes are made at each important street, road street, and open spaces. These scenes are inter-connected with the reference of a map so that traversal can be made from one scene to another.


Figure 4. Panorama and site information

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