Abstract. This paper presents a case study of the application of computer techniques for design communication and visual impact analysis. We were sponsored by China Light & Power Company Ltd. To simulate the design of a proposed electricity substation and its setting in a residential neighborhood. During a five-week intensive study, we took nearly one thousand photographs of the existing site. We also created a three-dimensional CAD model of the proposed substation, and produced perspectives from points of view analogous to the photographs. We applied Apple Quicktime VR technology to document the site environment with 360-degree panoramas. We then montaged the computer-generated panoramas with those taken from the real environment. A navigable virtual environment, architectural animation and set of still images were presented to the public in September 1998. The reactions from the regional council members and local residents nearby were recorded to provide evidence to measure the effectiveness of digital architectural design communication.

1. Introduction

Communication to the public is one of the vital functions of architectural design firms today, especially those that design public facilities. Architects always visualize and present projects to clients by various means. The challenge is to bring the three-dimensional reality of projects, existing site conditions, people and the design team’s experience into a visual format that can be communicated to the public, and to get feedback from them before the facility gets built.

As demand for electricity in Hong Kong continues to grow, CLP Power (one of the local power supply companies) must continue to expand its distribution system, including the construction of new substations. As with any large property owner, the company’s image is influenced by the design and maintenance of its structures and real estate - especially in proximity to neighboring property. The Department of Architecture, The Chinese University of Hong Kong (CUHK) studied the visual impact of a proposed substation at the Lee On estate and prepared a presentation for the local residents via digital architectural design communication techniques.

Computer technology provides the means to accurately project a proposed design into an existing neighborhood. The Lee On substation (figure 1) serves
as a case study for exercising this technology in a real-world setting, beyond the confines of the laboratory and classroom. For CLP Power, this project provides access to visualization techniques at the forefront of computer-aided architectural design that are not yet common in practice. For CUHK, this enhances the teaching and ultimately the professional practice of these techniques.

![Figure 1. Proposed electricity substation architecture.](image)

2. Project Scope

The emphasis of this project is on the appearance of the proposed substation as viewed from the neighboring property. The site is adjacent to a public housing estate (figure 2). Construction details and specifications are beyond the scope of the study. Our task was to predict and depict the substation's visual impact on the surrounding neighborhood, based on the available information. The research team will make no pronouncement regarding the suitability of the design.

3. Project Criteria

In developing the visual simulation, the team established the following criteria:

1. The computer-generated environment must have sufficient dimensional accuracy to overlay with the existing site surroundings for photomontage comparison.
2. Textures and colors should match the physical construction materials as close as possible.

3. Lighting conditions in the computer simulations should match the actual sky conditions at the site at the time of field data collection.

![Figure 2. Proposed substation is adjacent to a public housing estate.](image)

**4. Methodology**

This project emphasized the appearance of the proposed substation as viewed from the neighboring property. The site is originally part of the public housing rest garden. The shortest distance from the residential block to the substation boundary is 44.5 meters. Therefore, we had to present the environmental impact to the residents by comparing the current context with the one after the substation is built. The time frame for the whole visual simulation was limited to five weeks before the public forum.

As this was a five-week intensive study, the research team divided into three main streams in order to maximize both the effectiveness and efficiency of the visual simulation project. These streams are Context study, Architectural rendering and Design integration.
4.1. CONTEXT STUDY GROUP

The context study group documented the existing site environment with photos and Quicktime VR (QTVR) panoramas. All the photo-taking and QTVR node locations had been measured and marked on a detail survey map for the future overlapping between physical and virtual environments. The team took nearly one thousand photographs of the existing site. As a result, 28 panorama nodes were created, each consisting of 24 images (figure 3). We also obtained site survey and design drawings that indicate ground elevations, property boundaries, building footprints, roads, bicycle paths, footpaths, rest areas, and any other important neighborhood features from various sources. These drawings document both current conditions and proposed alterations, and cover the entire viewing area for the substation. This information is the key component that enabled us to match computer projections to photographs and panoramas of existing conditions.

![Figure 3. A set of 24 photos are stitched into one panorama.](image)

4.2. ARCHITECTURAL GROUP

The architectural group collaborated with the power company to obtain the detailed architectural plans, elevations, and exterior architectural drawings of the proposed substation. After collection of construction material samples and a color scheme study of the existing surroundings, the team using conventional CAD software to produce perspectives of the substation, and apply appropriate texture and shading on a computer model to generate computer renderings. The computer camera viewing parameters refer to the survey data from the context
study group. The three-dimensional computer's model was rendered from points of view that were analogous to the photographs of the existing site (figure 4).

4.3. DESIGN INTEGRATION GROUP

For the design integration group, we applied a hybrid approach of various digital design media to produce the final output, such as three-dimensional CAD modeling, image synthesis and photomontage techniques. The team combined and integrated the data generated from the context study group and the architectural group. We applied Apple Quicktime VR technology to document the site environment with 360-degree panoramas. We then montaged the computer-generated panoramas with those taken from the real environment (figure 5).
5. Project Output

The final package consists of computer animations, Apple Quicktime VR movies and a Powerpoint presentation distributed on CD-ROM. Live demonstrations of the navigable virtual environment, architectural animation and set of still images were presented to the public in September 1998. A total of about 50 local residents participated in the public forum. A series of photos and computer visualizations were shown to compare the difference of views before and after the substation is built from a variety of locations (figure 6). After viewing the simulation of the proposed electricity substation architecture, the residents participated actively in the discussion of the new design. We gained a valuable input from them.

Figure 5. A montage of computer generated panorama with photography panorama.

Figure 6. The visual impact evaluation from the public housing rooftop.
6. Conclusion

Apple's Quicktime VR provides a good foundation for modeling interactive virtual environments. The 360º panorama is very effective for documenting and simulating the substation itself and its surroundings, even before it gets built. It can combine photographs of the actual site conditions and computer-generated rendering to reflect the future environment. Once the research team assembled a set of panoramas, people can navigate and walk around their familiar surroundings with virtual architecture superimposed.

This project proved the viability of a computer visual simulation of electricity substation architecture in digital design communication. People from the public forum can have more insight and direct understanding of the changing neighborhood context. Their concerns regarding the view from their apartments had been addressed and put to rest. The simulation showed that the new substation would have little visual impact. It also served as a basis for discussion among the designers themselves regarding the fine points of architectural design, such as color and texture, in the context of the existing neighborhood.

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