

Integrating GIS, CG and the WWW for Facilitating Public Involvement in Urban Landscape Evaluation

Amin Hammad*, Kenichi Sugihara**, Naoji Matsumoto***, Shigeru Wakayama***, Yoshitugu Hayashi****

* Nagoya Industrial Science Research Institute

** Faculty of Business Administration, Gifu Keizai University

*** Department of Architecture, Nagoya Institute of Technology

**** Department of Geotechnical and Environmental Engineering, Nagoya University

Abstract: In spite of the widespread use of the Internet, its potential for facilitating public involvement in urban planning projects has not yet been exploited. In this paper, the possibilities and limitations of integrating GIS, CG and the WWW for facilitating the public involvement in urban landscape evaluation are discussed. It is proposed that off-the-shelf 2D GIS and 3D CAD software can be efficiently used for creating virtual urban spaces representing alternative landscape designs. The problems of synthesizing and publishing these data on the WWW are discussed, and a case study of evaluating the landscape of a public park is used to show the usefulness of the proposed approach.

1. Introduction

Active community participation in urban projects is an important factor for the success of these projects. Traditionally, explaining the details of an urban plan to local residents has been done using two dimensional technical drawings and, in some cases, sophisticated 3D perspective drawings and models that may provide more visual understanding of the project. These methods are static in nature and provide only limited interaction with the viewer (Nakagawa and Yoshikawa 1998). With the availability of high performance and low cost PCs and CAD software that are capable of performing landscape simulation, some researchers proposed the visualization of urban plans alternatives using 3D CAD simulation (Levy, 1995). However, preparing the data needed for the simulation from scratch is very expensive. Because of the increasing need of Geographic Information Systems (GIS) in the field of urban planning, a considerable amount of detailed GIS data sets are becoming available at comparatively low cost, and extensively used for the visualization of urban plans (Langendorf, 1995). Combining 2D GIS with 3D CAD and other multimedia data provides an efficient method for representing the present urban landscape and the modified landscape (Ligget and Jepson 1995; Gruber and Wilmersdorf, 1997). More recently, with the increasing accessibility to the Internet, and the possibility of publishing 3D landscape simulation data on the World Wide Web (WWW), the possibility to exploit this new media for urban space landscape evaluation has been proposed (Mitani et al., 1998).

In this paper, the integration of GIS, computer graphics (CG), and the WWW to facilitate public involvement in urban landscape evaluation is proposed. This approach explores the possibility of using the Internet to access and display 3D spaces with the Virtual Reality Modeling Language (VRML). This offers a practical and inexpensive

method to demonstrate alternative urban landscape designs to, and collect opinions from, the growing public who has access to the WWW. In addition, the flexibility in interacting with the scene makes it possible for the viewer to walkthrough or fly over the modified urban environment and compare several alternatives of the scene. A case study is used to show the usefulness of the proposed approach.

2. Role of Virtual Urban Spaces in Facilitating Public Involvement in Urban Landscape Evaluation

Although exact figures are not available, it is generally believed that the number of people accessing the web will grow from about 20 million today to about 200 million by the year 2000. At the same time, the computer processing power is expected to continue to double every 18 months, coupled with an expansion of the communication lines bandwidth. The potential of extending the 2D GIS representation of actual and modified urban spaces to 3D GIS spaces, enhancing these spaces with textures, lights, sounds, and other multimedia effects, and sharing these virtual reality spaces on the WWW, created a new research area usually called *the virtual city* (Dodge et al., 1998; Faust, 1995; Gruber, 1998). By analogy to the concept of the virtual city, new possibilities emerged for creating imaginary virtual cities, which have no direct relation with the real world. However, the discussion in this paper is limited to *real* virtual cities with augmented reality representing the changes in the urban environment.

The role of virtual urban spaces in facilitating public involvement in urban landscape evaluation and consensus making has three folds: (1) The role of presenting new urban designs visually to a large public with comparatively low cost; (2) The role of interacting with the 3D scene; and (3) The role of obtaining feedback from the public and sharing this feedback among the same public. The last role is of special importance and can be achieved by using on-line electronic questionnaires or BBS (bulletin board systems). These tools can effectively substitute conventional questionnaires used in the process of consensus making as in the case of Delphi method.

3. Requirements of Creating and Publishing Virtual Urban Spaces

The potential of the Internet for facilitating the public involvement in urban planning is becoming higher with the recent development of Internet GIS map servers, the availability of more integration of GIS and CG within both GIS and CAD software, and the availability of the VRML.

As an example of the integration of GIS and CG software, ArcView 3D Analyst extension, developed by Environmental Systems Research Institute (<http://www.esri.com>), enables users to integrate 3D data into their analysis by functions to create and modify surface models and simple three-dimensional vector geometry, as well as interactive perspective viewing, and the ability to export data to VRML format.

VRML is a non-proprietary open standard for manipulating 3D contents on the Web. The current version, VRML 2.0, released by the VRML Consortium in 1997, supports programmable behaviors necessary for creating virtual realities (Roehl, 1997). VRML files can be viewed by several independent browsers or plug-ins such as Cosmo Player (<http://www.cosmosoftware.com>). In addition, VRML files can be created and edited by specialized editors, or by exporting them from other CG and GIS software such as 3D Studio Max 2.5 from Kinetix (Miller, 1997; <http://www.kinetix.com>) and the above mentioned 3D Analyst. It should be noted that once 3D scenes are available, it is easy to produce static images and digital movies out of them that can also be published on the Internet.

Although this new approach of publishing virtual urban spaces on the Internet is becoming technically feasible,

several problems remains to be solved before it can be effectively used to facilitate public involvement in urban planning in general, and landscape evaluation in particular. These problems and some methods suggested in this research to overcome them are discussed in the following paragraphs.

3.1 The need for a practical method for data acquisition and manipulation

A major task in developing urban landscape simulation for studying the effect of an urban project is the input of the data necessary for this simulation. These data are of two kinds: the present urban landscape and the partially modified landscape resulting from some development in the built environment. As mentioned above, having a database of 3D CAD drawing can greatly improve the quality of the simulation and makes it possible to create photo-realistic representation of the scene. Preparing these data from scratch needs prohibitive cost and manpower. A considerable research work has been undertaken for automating the process of 3D data acquisition by using air-borne and ground-borne sensors and photogrammetry techniques. However, these methods are not developed enough to be applied for practical problems at reasonable cost. Another method is to produce approximate landscape simulation by combining available data from several sources using off-the-shelf software. These data are of two types (Table 1):

(1) GIS Data

A considerable amount of detailed urban GIS data sets are becoming available. For example, in Japan, two main sources of data are available for large cities: (1) Large scale GIS data (1:2500) of buildings, roads, etc., are updated annually and sold by several survey companies; (2) High precision landuse mesh data (10m mesh), landuse regulations, elevation data (100m mesh), etc. are updated and sold by the Geographical Survey Institute. GIS data of the present urban landscape including buildings, roads, elevation etc., can be used as the starting point in creating the scene (Ranzinger and Gleixner, 1997).

GIS data basically represent two dimensional map data. The polygons of buildings can have as their attributes number of floors or height of the buildings, type of structure (steel, concrete, wood, etc.), type of the roof (flat, inclined, etc.), type of the landuse (housing, office, shopping, etc.), and other attributes that may be used for constructing the approximate 3D representation of the buildings. By adding such attributes to the digital maps of buildings, a rough 3D representation of the volumetric distribution of buildings in the urban environment can be achieved.

(2) Texture Maps and other Multimedia Data

Texture maps of buildings' surfaces can be created by taking digital pictures of the buildings' facades or from material images libraries such as concrete, steel and glass texture images. Other 3D objects are necessary to add a touch of realism to the scene such as trees, street furniture, and human characters. Sound files, such as the sound of water or traffic noise, can be obtained from digital sound libraries. Light sources can be created easily by using the embedded functions of the graphical editing software.

3.2 The need to reduce the volume of data to be downloaded

One critical problem when publishing urban landscape simulation files on the Internet is the volume of data that need to be downloaded from the server to the user's machine before he can start navigating in the virtual space using his browser. On a standard 28.8kbs modem, with average network traffic, a VRML file of 150KB downloads in about 120 seconds. Another problem is the speed of rendering the VRML file during the navigation.

Table 1. Type of Data Needed for the Urban Landscape Simulation

| Type of data | Source | Required Data |
|--|--------------------------------|--|
| Elevation | GIS grid maps | 50 m mesh or less is desirable |
| Maps of buildings, roads, rails, rivers, etc. | GIS vector maps | Scale of 1:2500 or more is desirable |
| Buildings' height data | Attribute of building GIS data | Number of floors can be used |
| Texture maps of buildings | Material images libraries | A few number of concrete, steel and glass texture images |
| Trees, signs, street furniture, characters, etc. | 3D objects libraries | Representative objects reflecting the real urban environment |
| Lights | Created by CG software | Different kinds of lights |
| Sounds (water, traffic noise, etc.) | Digital sound libraries | Representative sounds |

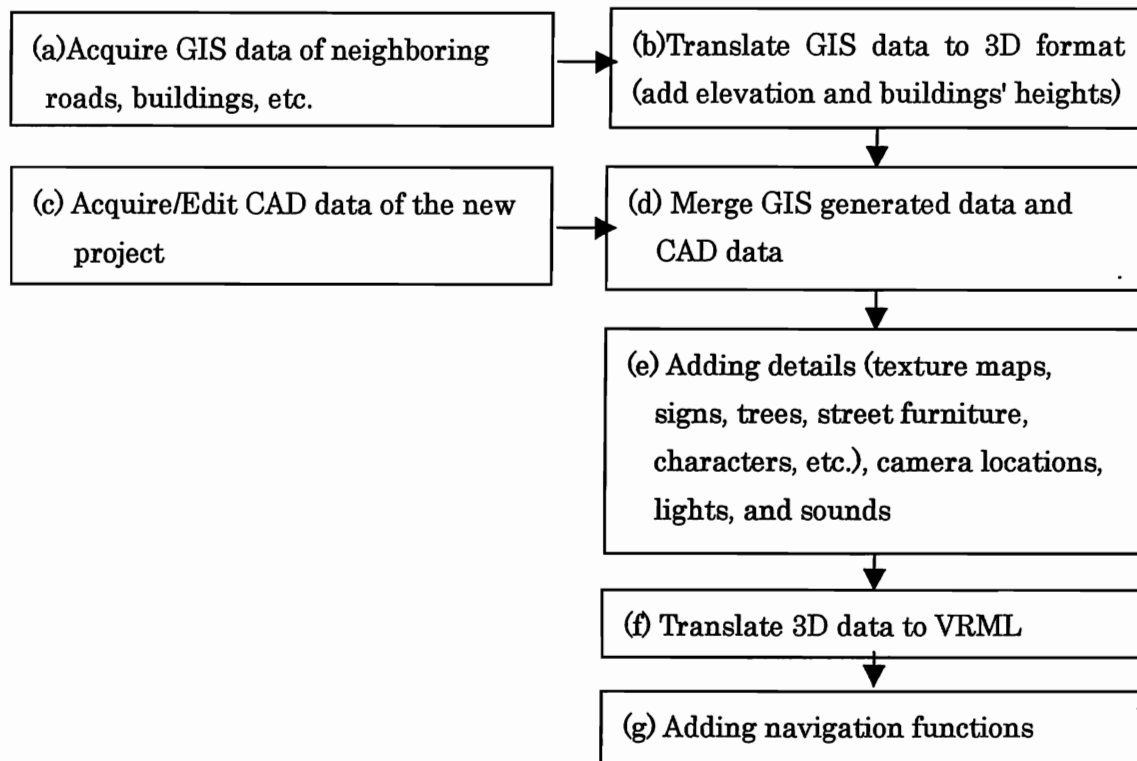


Fig. 1 Steps for Building Virtual Spaces for Urban Landscape Simulation

This speed depends on the performance of the video display of the PC, and decreases with the number of faces in the VRML representation. Therefore, every effort should be made to reduce this number by using VRML primitives and using texture mapping instead of geometrical objects.

3.3 Navigation problems

Commercially available VRML browsers such as CosmoPlayer have basic functions for interacting with the scene that makes it possible for the user to walkthrough or fly over the virtual urban space. However, it is desirable to add functions to facilitate this navigation following predefined paths or by adding predefined camera positions. More advanced applications should allow the comparison of several alternatives of the scene, and even make some additional changes to that scene interactively. These functions can be programmed with Java language.

4. Proposed Method for Creating Virtual Urban Spaces

The steps for building virtual spaces for urban landscape simulation are shown in Fig.1.

- (a) **Acquire GIS data of neighboring roads, buildings, etc.** These data are usually in separate layers of polygons, lines or points. Several formats can be used to store and manipulate these data such as the coverage format or shape file format of ARC/INFO.
- (b) **Translate GIS data to a 3D format such as VRML or DXF.** At this stage, the land elevation and buildings' heights will be added to the 2D GIS representation. Other attributes of the buildings, such as the type of the roof and the color of the buildings, can be used to add more details to the 3D model parametrically. The translation can be done automatically by using the export function of the GIS software, or be programs developed specially for this purpose. An example of the later case is to use MapObjects (MapObjects 1997) within the VisualBasic environment to access and manipulate the GIS data.
- (c) **Acquire/edit the CAD data of the new project.** The data of the new project are input using a 3D modeling software such as 3D Studio Max (Miller 1997).
- (d) **Merge GIS generated data and CAD data.** This step can be done within the 3D modeling Software simply by importing the translated GIS data and adjusting its location in the scene.
- (e) **Adding details** such as texture maps, signs, trees, street furniture, cars, static or animated characters, etc. Also, camera locations, lights, and sounds can be added at this step.
- (f) **Translate 3D data to VRML format.** This step can be done easily by exporting the scene from within the 3D software.
- (g) **Adding navigation functions.** If necessary, a user interface can be programmed to extend the navigation capabilities of the browser using Java language (Roehl et al. 1997).

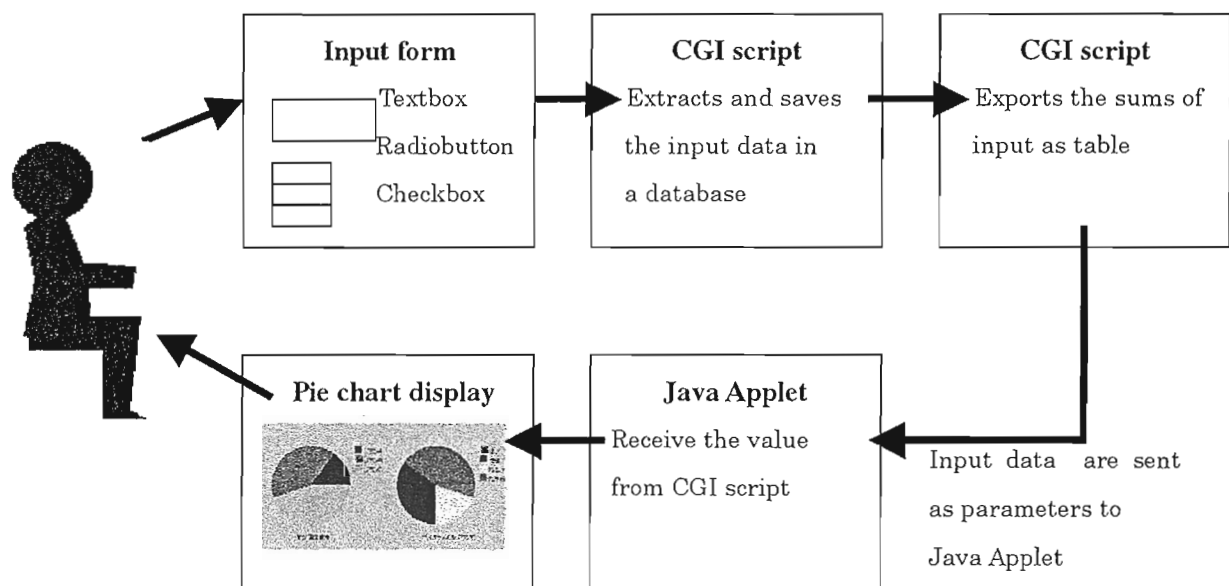


Fig. 2 Flow of the Implementation of an Electronic Questionnaire

5. Collecting Data on the Internet by Electronic Questionnaire

In order to get the public opinion and to form the consensus through the Internet, a questionnaire can be developed and implemented using HTML forms controlled by the CGI (Common Gateway Interface). The flow of the implementation of an electronic questionnaire is shown in Fig. 2. The CGI scripts, usually implemented in Perl

language, collect the answers to the questionnaire from the input form, sum up these answers to previously collected answers, and display the results by several charts. In the form, Radio buttons and Checkboxes can be used for multiple choice questions about the interests of the public in the project and its related issues. In addition, textboxes can be used to allow writing general opinions about the project and suggestions about its future use.

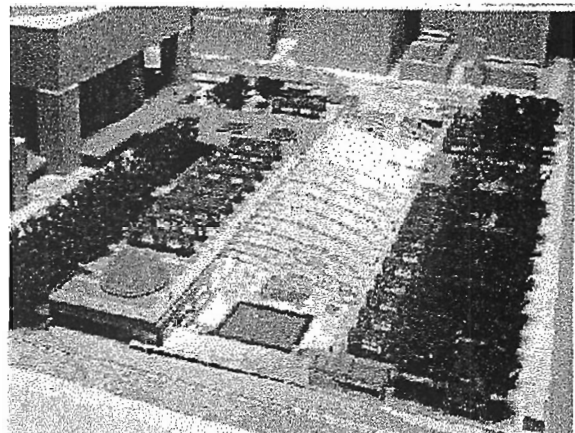
There are several ways to draw the graphs of questionnaire result on the server side such as GD graphics library. However, server side libraries place heavy load on the server, therefore, it is preferred to use Java applet to transmit questionnaire results to the client and to draw the charts.

6. Case Study

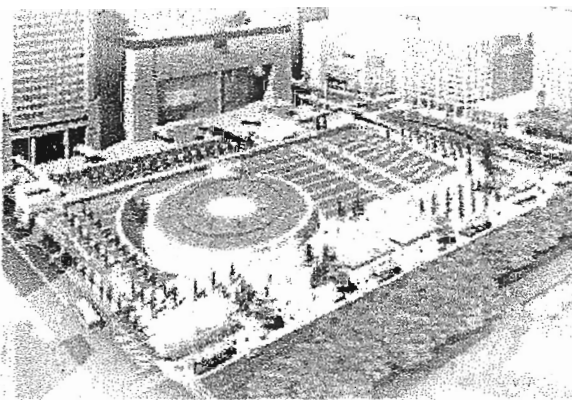
The case study examined in this paper is a project for the renewal of Sakae Park in the CBD of Nagoya City. In addition to the function of the park, This project adds the functions of an underground bus terminal with 21 bus stops, and shopping mall. The land area of project is 19,869 m². The neighboring buildings include Aichi Prefecture Culture Center and the Building of Japan Broadcasting Corporation.



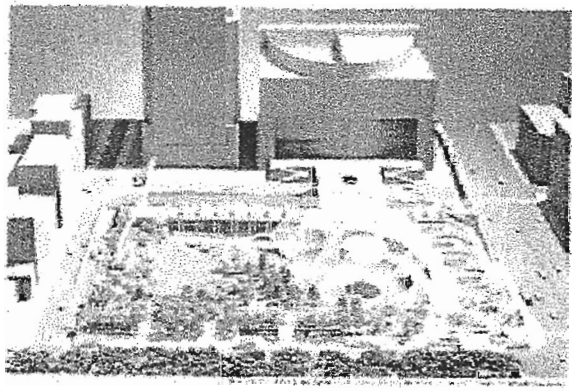
(a) A-Design



(b) B-Design



(c) C-Design



(d) D-Design

Fig. 3 Photomontage Images of some of the Proposed Designs (Sakae 1998)

Sakae Park was selected as the case study of this research because of the several aspects involved in its plan as a public project which were thought typical for encouraging public involvement. In the initial plan of the park, it was supposed to start the construction phase by 1996. However, few months before the start of the construction work, it was decided to reconsider the plan and to postpone it until 1998 for two reasons: (1) Some opinions were against building such large bus terminal in the middle of the CBD considering the expected decrease in the demand for bus public transportation; and (2) The estimated cost of the project, about 35 billion Yen, was considered too high after the end of the bubble economy period. The new plan resulted in reducing the area of the

Fig. 6 3D Presentation of the Park and Surrounding Area

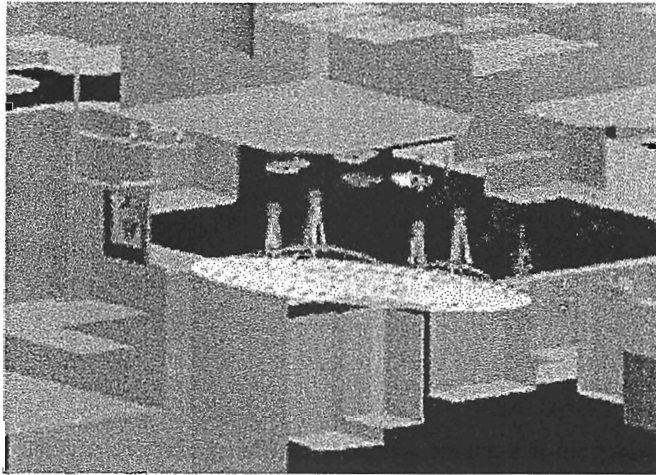


Fig. 5 Part of the 3D Presentation of the Winning Design Proposal

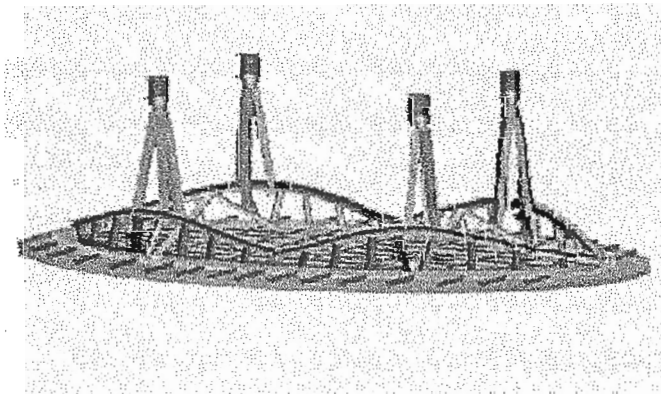
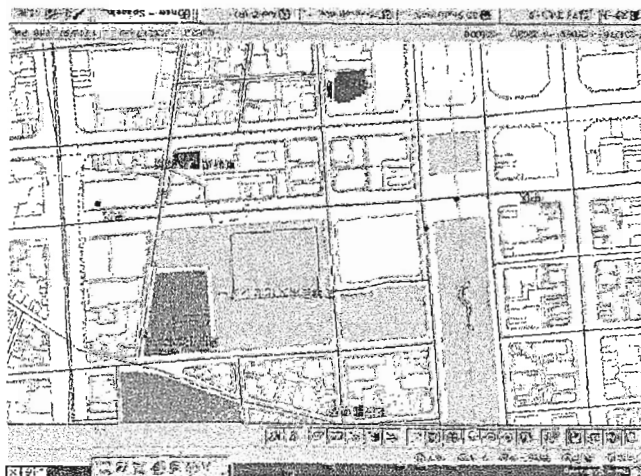


Fig. 4 GIS Map of the Area Surrounding the Park



bus terminal to one third, changing the design from two underground floors to semi underground, and reducing the budget to 20 billion Yen. A design competition was held for both the design and construction of the park. Fig. 3 shows photomontage images of some of the proposed designs submitted to the competition (Sakae 1998). The winning design (A-Design) has been selected by a committee of professors, designers and planners. The estimated budget of this design is 14.7 billion Yen with considerable amount of cost reduction.

Fig. 4 shows the GIS map of the area surrounding the park. Layers of 1:2500 scale of the roads, pedestrian areas and buildings were used. Fig. 5 shows part of the 3D presentation of the winning design proposal modeled with 3D Studio Max Ver.2.5. Fig. 6 shows the 3D presentation of the park and the surrounding area as can be seen on the web (<http://www.nisri.moriyama.nagoya.jp/sakae.html>). Several graphical mesh objects representing cars, trees, traffic lights, human beings, etc., were added from freeware archives. Because of the efficient integration of GIS and CG, the model could be developed in comparatively short time. In spite of the efforts made to reduce the size of the VRML final product, this size exceeded 3 MB because of the complexity of the structure of the park roof.

6. Final Remarks and Future Work

In this paper, the potential and requirements of integrating GIS, CG, and the WWW to facilitate public involvement in urban landscape evaluation were discussed and demonstrated with a case study. Further research is needed to compare methods for producing higher quality simulations with the minimum amount of data and to study the reaction of the public to this new media.

Acknowledgments

Mr. Masaya Minamikawa and Mr. Keisuke Kitagawa, graduate students at the Department of Architecture, Nagoya Institute of Technology, helped in the data input for realizing the case study. Their help is gratefully acknowledged.

References

- Dodge, M., Doyle, S. Smith, A. and Fleetwood, S. (1998). Towards the Virtual City: VR & Internet GIS for Urban Planning, Proceedings of Virtual Reality and GIS Workshop, London. (<http://www.casa.ucl.ac.uk/onlinepubs.html>).
- Faust, N.L. (1995). Virtual Reality of GIS, Environment and Planning B: Planning and Design, Vol. 22, pp. 257-268.
- Gruber, M. and Wilmersdorf, E. (1997). Urban Data Management – A Modern Approach, Computers, Environment and Urban Systems, Vol. 21, No. 2, pp. 147-158.
- Gruber, M. (1998). The Cyber City Concept from 2D GIS to the Hypermedia Data Base, Proceedings of the International Workshop on Urban Multi-Media/3D Mapping, Tokyo, Japan, pp.47-54.
- Langendorf, R. (1995). Visualization in Urban Planning and Design, Environment and Planning B: Planning and Design, Vol. 22, pp. 343-358.
- Levy, R.M. (1995). Visualization of Urban Alternatives, Environment and Planning B: Planning and Design, Vol. 22, pp. 343-358.
- Liggett, R.S. and Jepson, W.H. (1995). An Integrated Environment for Urban Simulation, Environment and Planning B: Planning and Design, Vol. 22, pp. 291-302.
- MapObjects: GIS and Mapping Components (1996). Environmental Systems Research Institute, Inc. Redlands, CA.
- Miller, P. (ed.) (1997). Inside 3D Studio Max, Vol. 2: Advanced modeling and Materials, New Riders, Indianapolis.
- Mitani, T., Yamanaka, H. and Kawaguchi, S. (1998). An Analysis of an Applicability to Space Design Valuation by Landscape Simulation Using a VRML Browser, Proceedings of the Japanese Planning Research Annual Meeting, JSCE, pp. 149-152 (in Japanese).
- Nakagawa, D. and Yoshikawa, K. (1998). A Role-Play Experiment to Measure the Effectiveness of Representation of Plans Using Computer Graphics for Obtaining a Consensus of Residents, Proceedings of the International Workshop on Urban Multi-Media/3D Mapping, Tokyo, pp. 167-172.
- Ranzinger, M. and Gleixner, G. (1997). GIS Datasets for 3D Urban Planning, Computers, Environment and Urban Systems, Vol. 21, No. 2, pp. 159-173.
- Roehl, B. et al. (1997). Late Night VRML 2.0, Ziff-Davis Press.
- Sakae Park Area Development Competition Report (1998). Committee of Sakae Park Competition (in Japanese).