Discovery of historical Tainan: a digital approach

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Abstract

This paper depicts the use of computers in the urban studies, and provides a digital way of understanding historical buildings and the relations with the city. “Discovery of Historical Tainan” is a joint project among historians and computer-aided design (CAD) researchers to preserve historical evidences of the central city of Tainan by using computer visual simulation. The importance of historical scenes is revealed by the efforts of integration with digital information and models. The process of modeling and the issues of computer visual simulation in the large-scale urban models are presented. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Recently, computer visual simulation is applied to architectural design, urban planning, environmental studies, and historical preservation [1–3]. Computer visual simulation can produce still images or animation based on computer graphics, and the use of it for experiencing spaces or evaluating the quality of spaces becomes easier and more economic than the physical model. Meanwhile, computerized city models are used as a platform for urban design research [4], and they are more helpful to understand the interactions among environmental experience, attributes and characters. Chiu [1] indicates the influence of computer simulation technologies on the built environment. Digital urban models can provide planners and people a visual communication tool, which can help better understanding of the characters of urban landscape and urban design procedures, and also the future development. Furthermore, ancient cities or ruins are also explored through computer simulation for examining historical evidences [5,6].

This paper depicts the use of computers in the urban studies, and provides a digital way of understanding historical buildings and the relations with the city from three levels, i.e. the building, district, and the city. “Discovery of Historical Tainan” is a joint project among historians and computer-aided design (CAD) researchers, which uses a digital approach to preserve historical evidences of the central city of Tainan. Therefore, the goal is to build a digital urban model and scenes, which can be used...
for historical and urban studies. It can be used to represent, analyze, and explore the past, current, and the future status of the city.

Lynch [7] indicates that three factors contribute to the image of the city: the identity, the structure, and the meaning. We are also imposing similar questions for ourselves in terms of the subjects of modeling, the process of modeling, and the rationale of modeling. Therefore, the discussion of the rationale, the process of modeling, issues in modeling, and the demonstration will be addressed in Sections 3–5.

2. The rationale of modeling

While a major part of this study is accomplished by computer modeling and simulation to reveal the importance of historical scenes, we spent more time to convince ourselves and historians to make the shift from the traditional approach of urban studies to a digital approach. A dialogue between the architectural historian and CAD researchers was raised with a series of questions such as:

What can we do about computers for studying historical buildings?
Why do we need to visualize the precedent or artifacts?
What can we know about the precedent from computer simulation?

Is that worth to study architectural or urban history by the computational tools?

The above questions provide the impetus for our thinking about the rationale of modeling. Historians search for the evidence as well as the facts and new views. Therefore, historians and designers handle large volume of information for their daily work. CAD can be used as a tool in discovering and recording the facts and views. Ancient people carved the artifacts in stone, now we are shaping the artifacts by bits with the help of computers.

Indeed, an image is worth more than a thousand words. People receive a strong perception from computer images, such as those generated from full-color rendered images. The lesson learned from architectural history is to validate the possibility of new views or theories. Computers provide a reconfigured eye for historians to examine the created digital world [8]. So far, computer simulation is more efficient than any other means for collecting and representing digital information.

In the past years, we continuously posed the above questions and had used computers for the following reasons:

(a) A recorder — We start to build a collection of text, graphs, images, and maps regarding the historical buildings and related literature, which can be useful for architectural or historical studies.

![Diagram](image-url) Fig. 1. Relationship between computer visual simulation and urban design.
(b) An organizer — We intend to classify the collected materials as mentioned by chronological or locational orders for historical preservation and computer simulation purposes.

(c) An analytic tool — We study the urban patterns with digital maps and models, and evaluate the feasibility of proposed new projects.

(d) A teaching tutor — We have built a multimedia database for teaching historical buildings varied from traditional Chinese architecture to colonial buildings.

(e) A virtual preservation method — We start to use the collected digital architecture for preserving and renovating historical treasures. Meanwhile, the virtual reality technology is used to experience the virtual space.

(f) A metaphor — We compare the perception of virtual spaces vs. physical space, and study the meaning of digital architecture.

Following the same approach, this study is undertaken to complete the following tasks: (1) to establish a 3D model of the central city of Tainan, (2) to
study the issues in modeling, and (3) to integrate
digital information into a multimedia database.

3. The process of modeling

3.1. Purposes of simulation

The main purpose of simulation is to reveal the
vision of the subject, urban design of a cultural
district that is integrated with national heritages, as
shown in Fig. 1. Therefore, different simulation
methods can be applied based on the needs and
technology to study various alternatives and changes
in different stages. A top-down process is used for
modeling from the city level, districts, buildings, to
details. We start to collect related references, such as
maps, literatures and photos, to build a visual plat-
form for urban design and historical study. The
integration with digital maps of the city provides the
foundation of modeling. However, the process of
modeling is more than just creating a digital model.
Meanwhile, data management is also important to a
collaborative project. The provision of information
up-to-date in the net becomes an unavoidable step.

3.2. A digital approach

Fig. 2 shows various approaches and tools for
transforming the verbal or visual description of arti-
facts to digital data representation. From an ob-
server’s point of view, the major concern is whether
the data representation can clearly deliver the actual
meaning of artifacts. It is critical to choose an appro-
priate way to represent the characters and attributes
of artifacts. While various tools are reported in use,
tools like photogrammetry, 3D digitizer, or virtual
reality has its limitations [2]. Particularly, the high-
end equipment is more expensive to operate and maintain. The justification lies in the quality and the economics for modeling and simulation.

We then adopt various tools at the same time based on the flexibility of data transfers and the availability of data. We clearly see the advantages of using the digital approach to simulate artifacts. Therefore, all materials have to be converted into digital formats. Raster-based and vector-based files compliment each other. Two-dimensional data, which are essential to presentation, are still largely used and can be converted into 3D data for further studies.

3.3. The city and the site

A historical, cultural city, Tainan, has a population of over 700,000. Its unique urban spaces are closely related with its cultural and geographic characters. Fig. 3 shows the outlines of the city in 1752. During the last 300 years, the city is slowly transformed, and Tainan is quickly losing its urban contexts because of man-made changes, such as demolition of landmarks, new infrastructures, and the relocation of local government offices to newly developed areas. From the urban development and historical point of views, records of the change of urban spaces will help better understanding the past and predicting the future development. To get an overall view of the city, we first built a 3D urban model based on digital maps and Geographic Information System (GIS). Meanwhile, how to represent a city of collective artifacts, memory, and experience by computer simulation is not just a technological problem, but also an urban study problem.

The realm of the Confucian cultural district is located in the central city (Fig. 4). The Confucian temple and the old city hall are the core of the district. The boundary of the site is defined by applying the concept of layering in CAD drafting, and is subject to many aspects of layers, such as nodes, path, districts, landmarks, and open spaces. Fig. 5 also shows the site studied in 3D. The distribution of historical buildings is the primary factor defining the boundary of the district. Within a 3-km-diameter range, 30 historical buildings are studied in-depth and indexed. The planned historical route for travelers will become the path that links the traffic nodes and future renovation projects. The Confucian cultural district is simulated at various levels of detail for identifying the historical significance (Fig. 6).

Table 1

<table>
<thead>
<tr>
<th>Mode</th>
<th>Level of abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Conceptual mode</td>
<td>Prototype (without openings) + (color)</td>
</tr>
<tr>
<td>(2) Articulated mode</td>
<td>Articulated massing (without openings) + (color)</td>
</tr>
<tr>
<td>(3) Imagery mode</td>
<td>Articulated massing + texture mapping (openings)</td>
</tr>
<tr>
<td>(4) Photo reality mode</td>
<td>Articulated massing + details + texture mapping (openings)</td>
</tr>
<tr>
<td>(5) Real mode</td>
<td>Massing + openings + details + full texture mapping</td>
</tr>
</tbody>
</table>
3.4. Data management

In this project, the working group consists of experts from multidisciplines, such as historical preservation, urban design, landscape architecture, traffic management, and CAD. Design guidance was defined based on the discussion and observation from the streetscape created by visual simulation. Data management is critical for a collaborative project that all participants need to access the basic information. A visual database is created on the World Wide Web for demonstrating the current status of project work. The web becomes a repository of this project. Data organization is determined in accordance with the working status and the purpose of uses.

4. Issues in modeling

Radford et al. [9] indicate that issues of abstraction, accuracy, and realism in large-scale computer urban models are critical to its performance. During the modeling process, these issues are also raised in our study. Meanwhile, from the historical point of view, it is also critical to know how to represent urban contexts and building details in the past, current, or the future. Time span is added to the fourth dimension of modeling.

4.1. The level of abstraction

The determination of the level of abstraction is generally based upon the scale and volume of artifacts and, consequently, it will affect the computational performance and visual quality. Table 1 shows that five modes of modeling are used in the study, and the result is shown in Fig. 7. The conceptual mode is the simplest mode that the prototype of artifacts is used to represent the reality. It is often used in large-scale models as shown in Fig. 4, and the openings, such as doors and windows, are typically ignored in modeling. On the contrary, the real mode is to model the artifact as real as possible, and

Table 2
Comparison of the results of rendering

<table>
<thead>
<tr>
<th>1. Articulated mode</th>
<th>2. Imagery mode</th>
</tr>
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<tbody>
<tr>
<td>3. Photo reality mode</td>
<td>4. Real mode</td>
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</table>
it has greater level of detail and larger number of polygons. In the study, the level of abstraction or details is determined and assigned to each artifact according to the importance of buildings and the complexity of geometry. Generally, the landmark buildings and historical heritages are assigned to the real mode of modeling for the identity.

A preliminary test is performed to examine the difference of visual quality and computational performance. The last four modes are tested on the basis of using computer hardware with a Pentium-II 233 MHz CPU, and 128 MB RAM installed, and the software 3DS MAX. The models are tested with the same light source (one spotlight + two omni-light).

To achieve the similar visual perception as the other modes, the articulated mode is enhanced by adding textual mapping generated from the real mode. Table 2 compares the visual perception of these four modes and found that are all acceptable while the shading effects in four modes are different and can only be distinguished at the close distance.

However, the computational performance of four modes is different due to the geometry. The rendering time is changed from 20 s to 3 h because the number of faces or polygons is dramatically increased. Fig. 8 shows the computation time is increasing slower than the growth of the number of faces. Nevertheless, the articulated mode (1) or the imagery mode (2) is still suitable in large-scale urban models or the VR environment, and the photo reality mode (3) or the real mode (4) is suitable for small-scale buildings.

4.2. Large-scale rendering

Computer visual simulation is time-consuming due to the size of data volume, particularly in large-scale urban studies. The polygon size of the urban model

![Fig. 8. Comparison of the performance.](image)

![Fig. 9. City changes from 1874 to 1997.](image)
is about 2 million. In general, digital models have to be classified according to the level of scale and detail for various uses. We then analyzed three alternatives of large-scale rendering, including (1) the use of high-performance workstations or supercomputers, (2) networked rendering, and (3) synthesis of partial renderings by separation of rendered areas. While more effective, the first one normally accepts limited file formats and errors often occurred when transfers of formats. The third alternative requires careful plan of foreground and background, and definition of control viewpoints. Therefore, we adopted the networked rendering approach, and four to six PCs are networked for rendering under Windows NT4.0 and 3DS MAX R2.5. The estimated rendering time of using three networked PC is reduced to one-half of the time when only one PC is used. It proved to be more economic.

4.3. Accuracy

Buildings are the major artifacts of the model. In order to simulate the impression of a view, accuracy of the location, geometry, color, and textures of buildings are important for our understanding of the past, existing and future environments. Besides buildings, their surroundings, such as road, plants, and street furniture, can enhance the realism of visual perception. However, some artifacts are necessary to maintain the abstraction of geometry or form. For example, a 50-year-old banyan tree may have 1 million leaves, and it is necessary to reduce the number of polygons to a managed level.

4.4. Artifacts changed over time

The timing of the artifacts is critical to historical study. Because buildings are changed during the time, it is also important to know the status of modeling. Fig. 9 illustrates that several changes of the city occurred from 1874 to 1997. For example, Fig. 10 illustrates that three phases (year 1916, 1996, 2000) of the old city hall are slightly different in roof structure due to renovation. Then we have to maintain a profile of each major artifact with several models. Similarly, infrastructures, such as roads, may be changed, then the model need to maintain the flexibility of modification. Then the databases have...
to be developed in accordance with time as shown in Fig. 11.

5. Integration with digital media

5.1. Prospective projects

This study proposes several projects of reusing historical buildings in order to revitalize the area. Therefore, prospective projects are simulated and studied. As shown in Fig. 12, the urban model is used as the foundation to study the past and future changes. For example, the old city hall will become the national heritage conservation center, and the old courthouse is planned to be an art museum.

5.2. Interactions on the web

It is also important to understand how to observe the characters of urban space from the digital model, and how to access the model by people to understand the urban issues and problems. We first examine the model based on Lynch’s [7] notions on the elements of urban image, such as paths, edges, districts, nodes, and landmark. Planners and people are invited for evaluating the digital model from the street level and the air. The web is located at http://www.arch.ncku.edu.tw/project/confu/, and serves as the repository for digital images and models of the project for the public. A simplified virtual reality model of streetscape is implemented on the web now (Fig. 13). Ideally, these will encourage civil participation in planning, and provide feedback to the planners. Frequent updates of the projects and online questionnaires provide more interactions among planners and users.

5.3. Multimedia database

A multimedia-based presentation creates better visual perception than the traditional media. “Visiting the Tainan Confucian Temple” is prepared as the CD-ROM format and distributed for participants during the public hearing session. Images, animation, self-guided tours, narration, and sound effects are
integrated in the multimedia database to understand the concept of preservation, historical meaning, and the development of the city during the last 300 years. Fig. 14 shows some snapshots of the CD-ROM.

6. Conclusion

The lesson learned from the above exploration and implementation of using CAD proves to be a feasible way for historical and urban studies. Computer provides a vivid crystal ball for historians to examine the created digital world. Indeed, computer simulation becomes affordable and is an efficient approach for architectural studies. In conclusion, this paper provides a digital approach to understand the historical buildings, and various examples are shown for highlighting the above points. From the research aspects, the level of abstraction, accuracy, and database management in the large-scale urban models are examined. This study shows that extending the usefulness of CAD beyond the computational theories is critical for future CAD research. CAD users also play an important role in CAD research by providing directions and reflections.

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References