Incorporating A 3D Urban Environment Model Between Government And Local Architectural Firms

Naai-Jung Shih and Wei-Jeh Lan
Department of Architecture
National Taiwan Institute of Technology
E.mail: shihnj@mail.ntit.edu.tw

Abstract

The purpose of this paper is to study how to incorporate current modeling data with design under constraints of current computational capability and applied software and hardware of local architecture firms. The study is made to facilitate the review of newly designed buildings and evaluating their possible impact on the surrounding environment. Concerns regarding the operation of government's departments and local architectural firms, the design and application of 3D urban environment model (3DUEM), and visual representation are also discussed. This paper concluded that a 3D computer model for evaluation will fundamentally change the design data and process an ordinary architecture firm performs. Similarly, 3DUEM may change traditional design approach, for example, from 3D models to 2D drafting data and from the concern of the scale of urban environment to the design of a building.

1:Introduction

The purpose of this paper is to study how to incorporate current modeling data with design under constraints of current computational capability of local architecture firms. Instead of comparing different modeling or simulation systems, the primary goal of this paper is to analyze government's operation procedures, the limitation of local firms, analysis of modeling modes. Although selecting a better CAD system to simulate urban environment can help designers incorporating buildings with urban models, solving the operation and data transfer barrier can really help designers benefiting from it in an actual CAD environment.

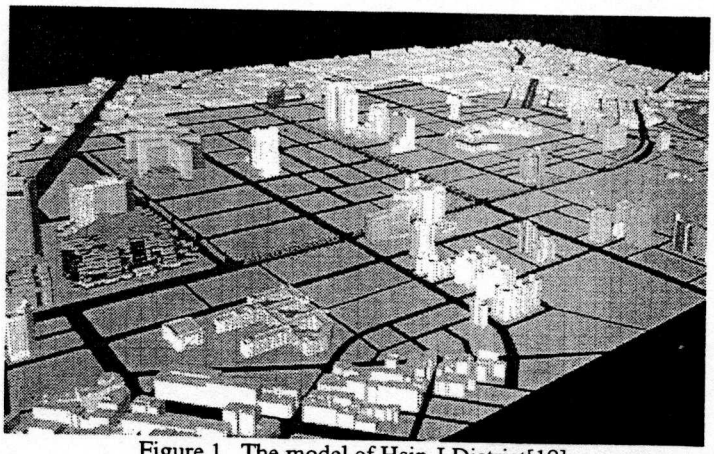

Figure 1. The model of Hsin-I District[10]

The Taipei City Government established a 3D urban environment model (3DUEM) to facilitate the review of newly designed buildings and to evaluate the possible future impact of the design. The application of 3DUEM is used to control the urban environment of Taipei. The effort is first being tested in the Hsin-I District which has almost the quickest development of commercial activities in east Taipei. Similar effort will later be applied to other districts of the city. The Government considers reviewing building design in terms of the broad environment an important control method of city landscape. Starting from Hsin-I District, a six-month project was conducted to build a 3D environmental model. The model associated with other objects of urban furniture like landscape, pavements, and pedestrian lights will be used by both the Department of Urban Development and architectural firms to evaluate each newly designed building in the district. Several new buildings, which are to be built or still under

construction, are also included in the model in order to simulate the urban environment in the future (see Fig. 1). The simulated result includes pictures of specific orientations at some important locations from the viewpoint of pedestrians or drivers. The result also includes animation along the sidewalk.

Most of current architecture firms still use 2D drafting functions as their main CAD production tools, instead of 3D models. Related studies show two sets of survey data made to architecture, engineering and construction (A/E/C) firms. The first survey, which was distributed to 110 firms of filtered AIA members, shows 74% of the firms use AutoCAD as their CAD package; 87% of the firms regularly use computer at the stage of construction drawings.[6] Similar type of survey was also made of 92.6% of local architects (1599 out of 1724 architects nation wide). The result showed 74% of the architecture and construction consultant firms use AutoCAD, and the package is mainly used to draw construction drawings.[2] The type of data and the firm's ability in manipulating or creating 3D data may cause difficulties when government requests 3D computer models during inspection process.

2:Visual representation

The difficulties in manipulating or creating 3D data come from the demand for visual representation: visual studies are conducted to new designs occurred in the model. In order to model a new design and surrounding environment correctly, a firm has to know the items which are of particular importance to government's inspection. Some of the items (see Tab. 1 in Section 6) directly involved in building inspection.

In addition to including items for building inspection in urban model, visual representation of design and urban environment has strong influence to the final images generated. The representation is related to the amount of details, viewing information, and backgrounds which should be considered as references in evaluating architecture firm's performance in incorporating with government effort and manipulating design data.

- Amount of details: A certain balance has to be reached between the amount of details and computational capability in order to conduct a realistic and meaningful simulation. A question is usually raised: how mush detail is enough? In the real world, a city consists of a great number of details, such as buildings, advertisement boards, landscape, cars, people, furniture, etc. The number and variety of contents represent the physical as well as visual details of an environment. In order to build a 3DUEM which can facilitate design study, a great deal of detail has to be included before conducting a convincing simulation.
- Viewing information: Perspectives at certain locations have to be provided to the reviewing committee to examine the impact of a new design to the city environment. In order to provide realistic simulation, an animation should be generated. An animation allows observers to perceive the environment continuously, instead of through static images with a restricted viewing angle. In addition, the models should be built in an interactive environment which allows observers, including designers and committee members, to directly manipulate the images with a translated viewing point, changed viewing target, zooms in/out, panning, or walking through.
- Backgrounds: Although existing buildings act as part of the urban background for new building design, there are other details in backgrounds that should be taken into consideration. For example, urban scenes can differ from morning to night. A city at rush hour appears quite differently from the scene during holidays. A building at 12:00 noon time is also very different from the same one at night when all the lights are turned on. If the evaluation and comparison is only made at a certain period of daytime with a fixed background, the whole scene can be mis-leading due to certain missing aspects.

3:Operation of departments and administration office

In order to share the 3D data urban environment model (3DUEM) with local architectural firms, several concerns were raised regarding these involved procedures.

Related departments, which are responsible for traffic and urban planning, also contribute to the construction of city facilities like roads and public buildings. All the public facilities to be constructed in the future should be included in the 3DUEM. In fact, when an expressway connection between the east and west parts of Taipei was added to the model, its future influence to the urban environment was clearly demonstrated.

The department of Taipei City Government has existing graphic standards which are well-established and have been used for a long time. In order to incorporate a new urban model, several internal operations have to planned:

- connection between old and new systems: Existing systems are based on PCs and Workstations. Connection between the two systems has to be through another format. In addition, a very large amount of existing data like GIS has to be incorporated with new urban data.
- system's computational capability: If all types of data are integrated from different departments, the amount of data will consume the system's computational capability. Currently the data is used separately from other departments.
- management of public access: To make the best use of 3DUEM, a network allowing public access should be established to transfer data between local firms and governmental departments. If different file formats are involved, data transfer also includes translation.
- promotion strategies: Building review committees are going to include simulation as a standard

reviewing procedure. Design firms are encouraged to use the urban model to conduct the same study during any design stage.

- data maintenance: This maintenance includes data updates that add, delete, or modify the existing database of 3DUEM. This task has to be the responsibility of a specific department to ensure its long term execution.
- the feasibility of 3DUEM: The government may not want to include enough details in order to prevent data overload. The feasibility of 3DUEM has to seek the balance between the efficiency of computational capability and the amount of detail in visual representation[8].
- training program: In order to introduce the new data to outside firms and other government departments, a training program has to be designed when 3DUEM is used and whenever it is updated.

4:Limitation occurred to local firms

Local firms may not meet the computational performance of the government's computer system, but still have to execute visual simulation with the whole set of urban data. Several concerns are listed:

- file transfer: Two levels of transferring are involved. This includes the retrieval of 3DUEM from the government's database and retrieval by government's reviewing department. Sometimes retrieved data has to be converted to the format acceptable by a firm's application if different software for modeling or visualization is used.
- system compatibility: In order to run data retrieved from the government, it's better to have the same system platform as the government does. In the first stage of 3DUEM establishment, an Architecture Engineering System (AES) on workstation was used by government. The system has a different data format from AutoCAD and 3D Studio on PC, the most commonly used systems by local firms. Although a common DXF file format can be transferred, the compatibility between the two systems has to be solved before seamless connection is achieved.
- computational capability: 3DUEM covers an entire district of an urban region. The amount of data was simulated on a workstation whose computational capability exceeds normal PCs. Most local firms would not be able to handle the same amount of data with superior speed. How to reduce data amount and accelerate rendering speed becomes an important issue in gaining acceptance by public. Currently, local firms are allowed to load their design data onto the reviewing committee's workstation to perform simulation.

74% of local firms use CAD tools for drafting purpose only [2]. The major type of data they use for visual representation is 2D drawings. In general, the details of 3D visual representation are in proportion with the quantity of data. However, local situation is in reversed order (see Fig. 2). Same relationships occur to man-hour spent on different types of visual representation and the demand for corresponding software and hardware. CAD contractors, which specialize in 3D modeling and animation jobs, have more feasible software and better hardware to accomplish similar tasks. Local firms actually can generate 3D models, but the models are usually not required by clients. In general, capability of local firms should exceed the capability merely represented by their demands.

- the ability to build 3DUEM of local firms: Most of local firms use 2D-oriented drafting applications for working drawings[2]. 3D simulation is seldom conducted unless required by clients. The ability to build 3DUEM is a great concern when a 3D model is required by a government reviewing committee.
- networking: In order to transfer 3DUEM to and from local firms, a network has to be established.

5: Analysis of feasible modeling modes

Based on the requirement of visual representation, limitation of local firms, and government's system environment, modeling purposes have to reviewed to fulfill simulation needs. According to the detail and surface attributes applied, the reality of a building model varies between the representation of conceptual and detail models or plain color and image/texture.

- conceptual or detailed representation: A mass model is a type of conceptual representation, in contrast to a detail model which includes building components such as roofline, balconies, or openings.
- plain color or image/texture representation: In addition to building components, surface attributes which affect final visual appearance of a building are represented[4]. The detail of visual appearance can vary from plain color to textures.

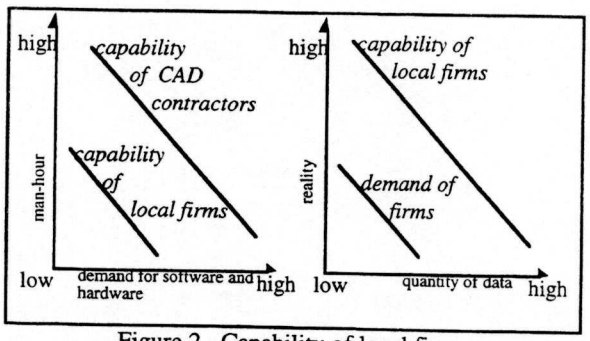

Figure 2. Capability of local firms

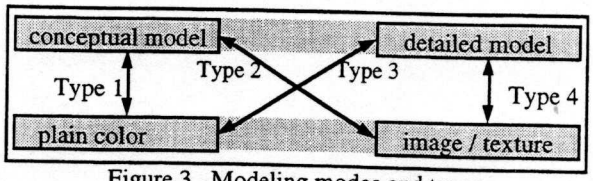

Figure 3. Modeling modes and types

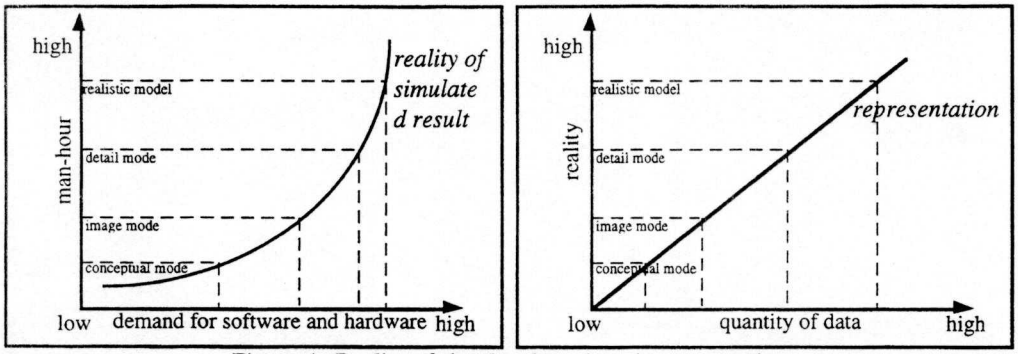

Figure 4. Reality of simulated result and representation

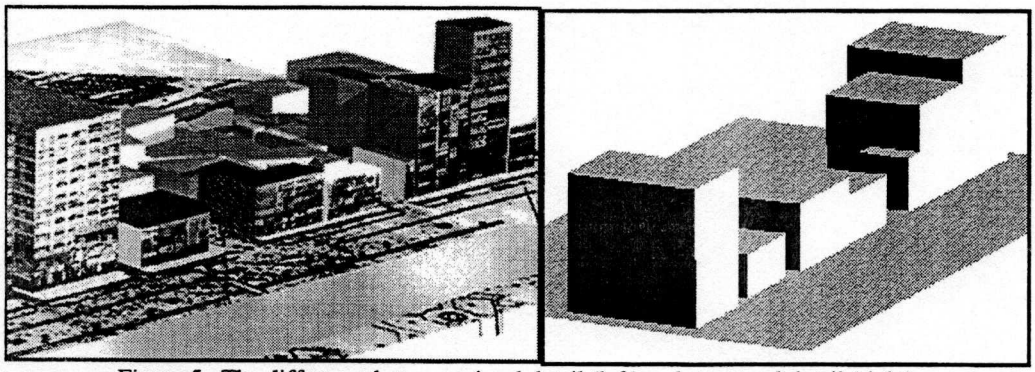

Figure 5. The difference between visual detail (left) and structural detail (right)

The combination of two modes generates four types of modeling relations (see the Fig. 3). Each type may be applied to both background and foreground. The 3DUEM not only has to evaluate new buildings, but their influence on the existing environment. The relation between reality of simulated result and representation in terms of man-hour and reality is shown in Fig. 4.

- Type 1 - plain mode: Mass model and plain color are applied to buildings. Simple geometric primitives are used to represent buildings which are only colored for different purposes like functions or zones. This mode is suitable for layout in conceptual design or for the part of models which do not need to be emphasized
- Type 2 - image/texture mode: Buildings are represented by simple geometric primitives whose surfaces are textured with images taken from real facades or the urban environment. This mode, which is suitable to quickly build models in a simple form, still can reflect the appearance of buildings. Since an image is pasted on a flat surface, all the details regarding depth will not be shown. This mode can be used to model buildings around a design project.

An alternative was suggested to solve the representation of details. By differentiating visual and structural details (see Fig. 5), buildings can be constructed with simple forms and later be assigned with images as textures to all surfaces[1]. Since images taken from the real environment can display very complicated visual information, visual detail can be enhanced without significant effort.

- Type 3 - detail mode: Buildings are detailed models with plain colors.
- Type 4 - realistic mode: Models needs to be built by using an appropriate 3D modeling application with texture mapping. Buildings are modeled part by part as described in working drawings. The final result is very realistic; however, the modeling process is very time- and effort-consuming.

Due to the vast amount of data that has to be calculated while rendering a perspective, an alternative was suggested that pictures be rendered at a specific location and orientation.

6:Feasibility study of local firm's 3D modeling capability

Realistic mode has the best modeling quality and the highest man-hour consumption (see Fig. 6). The rest are detail mode, image mode, and conceptual mode. Most of the local firms only use the 2D functions of applications to generate working drawings[2]. The capability of local firms to model is distributed in the lower-left region. Increasing the reality of simulation is related to the demand for appropriate software and hardware. Many firms contract out modeling and rendering jobs to specific agents. The capability of representation is related to the reality and the quantity of data (see Fig. 7). The demands

for the modeling reality of local firms is lower than the capability of what they can provide by their own facilities.

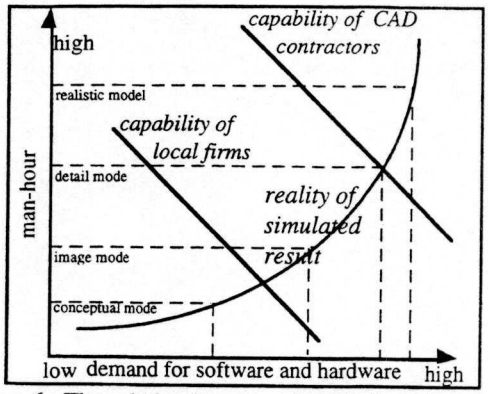

Figure 6. The relation between simulated result and the capability of local firms

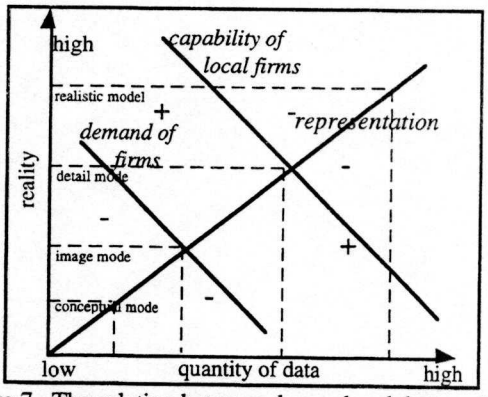

Figure 7. The relation between demand and the capability of representation

Table 1. The relation between the four modeling types and inspection items

evaluation items	1	2	3	4	5
conceptual mode	-	+	+	-	-
image mode	+	+	+	-	+
detail mode	+	+	-	+	+
realistic model	-	-	-	+	-

The relation between the four modeling modes and inspection items is categorized in Tab. 1 in which "+" represents strong relationship, "-" represents weak relationship. The inspection items are:

1. building form: pitch roof, roof additions
2. building height and mass
3. building color
4. open space: side walk, street trees, green space, perimeter wall, pavement, handicap access, lighting
5. planting plan for legal open space

Although images derived from elevation drawings or photos can be used as texture and pasted on the surfaces of building blocks, this method which conducts a relatively easy task only leads to limited detail representation comparing to extruded or recessed parts of building surfaces. Since the simulation of urban environment is conducted to exterior spaces, the details of 3DUEM can be reduced by merely modeling the part of building related to a building's appearance. In other words, only exterior walls and containing parts are modeled.

Constructing a 3D computer model for evaluation will fundamentally change the design process an ordinary architecture firm performs. To include enough design information, 3D models have to be built to reach certain level of detail. The 3D details of roofs, walls, openings, skylights, floors, and other building components will refine the information included in old data type[3]. In addition to reaching coherence in urban environment, the design quality can be promoted due to the substantiation of 3D design data.

The requirement of 3D environmental data for evaluation at governmental level promotes the preference and occurrence of similar study in a firm. This is an enforcement of a simulation environment. Being able to manipulate a building's shape and size during the design process becomes very important and desirable by most designers in determining the final result[5,7]. Similar 3D functions may fundamentally change traditional design approach, for example, from 3D models to 2D drafting data [8,9] and from the concern of the scale of urban environment to the design of a building.

7:Design and application of 3DUEM

In order to be used by local firms, 3DUEM has to be carefully designed to facilitate visual representation. 3DUEM will be established from two sources: the building data submitted from local firms and the urban models of other part of Taipei city continuously built by contractors like this one. In order to facilitate future application of 3DUEM, several concerns have to be considered:

- objectives of data: The 3DUEM has to be correctly built to represent the information about the environment which could be critical to design. The information includes volume, color, materials, landscape, etc. which will later be used to study the skyline, proportion, or adjacency of buildings.
- design of 3DUEM data: The 3DUEM will be required to combine GIS information to conduct other types of estimation like sensor or area data for administration purpose. In addition to the data structure or database design, the 3DUEM is hierarchically constructed, for example, in a building - block - district level to facilitate the management and retrieval of data.
- effectiveness of representation: This is determined by the amount of data that can be handled by local firms. Too few data may not be enough to represent real urban environment; too much detail may prevent local firms from using it due to limited computer capability.

- integration of data: The 3DUEM has to be incorporated with old urban data which has been collected for a long period of time.
- precision demand: A newly designed building has to be modeled precisely in order to be evaluated correctly. The precision required for an urban model may not be the same level as that of submitted buildings, however, a certain level is still required in order to display appropriate relationships.
- coding buildings: In order to well-categorize urban information, each building is coded with x-, y- and z-coordinates on the city map. The coordinates facilitate the management of database in terms of retrieval and future insertion of new buildings. Architectural firms can also identify buildings which may have influence on their new designs and request the data useful to them.

8:Conclusion

During the six months of this project, one of the authors was asked by the city government to participate as one of three consultants to advise how the data can be established and used by the public in the future with less difficulty. Most of the discussion states related concerns and how solutions to the concerns were eventually found. The experience may help government department and architectural firms to manipulate design more effectively.

Although the result of incorporating government's effort and local firm's computational capability is yet to be seen in a few years, there is no doubt that computer simulation can be used as a tool to evaluate design quality in an urban environment. Appropriate modeling methods can facilitate the efficiency and effectiveness of simulation. The environment model can provide related government departments, committees, or local architectural firms with realistic design references. Most important of all, constructing a 3D computer model for evaluation will fundamentally change the design process an ordinary local architecture firm performs. Similar 3D functions may fundamentally change traditional design approach, for example, from 3D models to 2D drafting data and from the concern of the scale of urban environment to the design of a building. The Taipei example will be extended to other parts of the city, and eventually to all the metropolitan areas in Taiwan with an improved application of 3DUEM.

Acknowledgments

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