# TOWARD A COMPUTERIZED PROCEDURE FOR VISUAL IMPACT ANALYSIS AND ASSESSMENT

*The Hsinchu example*

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**Abstract.** This paper examines the procedure of visual impact analysis and assessment proposed by Rahman and reviews the use of CAD applications in urban projects in the real world. A preliminary computerized procedure for visual impact analysis and assessment is proposed. An experiments was conducted in our laboratory to verify the preliminary procedure. In order to further study the revised procedure in real urban projects, it was also applied into the renew project of The Eastern Gate Plaza located in the center of city Hsinchu, Taiwan from 1996 to 1998. According to several face-to-face discussions with Hsinchu habitants, government officials, and professional designers, a final computerized procedure for visual impact analysis and assessment is concluded.

## 1. Introduction

Computer-aided design (CAD) systems have been widely used in different stages of architectural design, interior design, and landscape design. Thanks to the studies on the relation between design processes/methods and computer technologies (Lawson 1995; Liu 1996), computerized design processes/methods have been emerging since 1990. As a result, many new styles of architecture have been created such as the buildings designed by Frank Gehry and Peter Eisenman (Jencks 1995; Liu 1998). In addition to the use of the computer in the architectural design process, there is also a need for the computer to be involved in the processes of visual impact analysis and assessment in urban spaces (Rahman 1992). This study thus intends to provide a new, computerized procedure for visual impact analysis and assessment based on the maturity of the use of image processing/synthesis, three-dimensional modelling, multimedia, animation, and the newly-developing virtual reality (VR) technology.

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This paper begins with re-examining the procedure of visual impact analysis and assessment (VIAA) proposed by Rahman (1992) and reviewing the use of CAD applications in urban projects in the real world. A preliminary computerized procedure for visual impact analysis and assessment is then discussed. This procedure includes the analysis for site organization, 3D volumetric composition, 2D elevational composition, and off-site viewing conditions as well as the use of image processing/synthesis, 3D modelling, multimedia, animation, and VR in different stages. Two experiments were conducted in our laboratory to verify the above preliminary procedure. Professional designers and non-experienced city habitants were selected as subjects in the two experiments respectively. Based on the analysis of the empirical data, the preliminary computerized procedure is revised. In the revised procedure, the multimedia and VR technology become more important in the early stages. In order to further verify the revised procedure in real urban projects, it was also applied into the renew project of The Eastern Gate Plaza located in the center of city Hsinchu, Taiwan from 1996 to 1997. According to several face-to-face discussions with Hsinchu habitants, government officials, and professional designers, a final computerized procedure for visual impact analysis and assessment is then concluded.

## 2. Background on visual impact analysis and assessment

What kinds and how many design factors should be involved in the procedure of visual impact analysis and assessment (VIAA), especially those applicable to urban projects, have been widely discussed (Bentley et al. 1987; Peterson and Brown 1986; Tugnutt and Roberson 1987). Rahman (1992) proposes a checklist of design and visual criteria in attempting to come up with a generalized procedure for VIAA as shown in Figure 1.

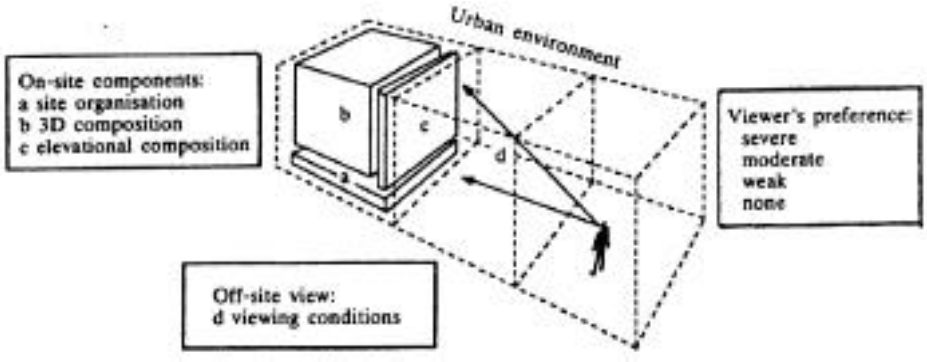



*Figure 1.* Analysis of the external physical features of any project in relation to the percipient (after Rahman 1992).

In the checklist, several design and visual factors are identified and grouped as the following four categories:

a. site organization: pedestrian movement, vehicular movement, alignment, landscaping, topography, plot size.
b. three-dimensional composition: general form, articulation, skyline, height, transition, projection.
c. elevational composition (two-dimensional): overall style, rhythm, color, materials, details, texture.
d. viewing conditions: solar glare, artificial lighting, view obstruction.

In addition to suggesting the use of traditional media to use in the VIAA design process, Rahman (1992) also mentions the importance of computing media including 3d modeling and animation (Figure 2). Because various computing media have been effectively used during different stages of the design process (Liu 1996, 1998), computing media involving image processing/synthesis, 3D modelling, multimedia, animation, and VR can play a more important role during the VIAA design process as the shaded areas in Figure 2.

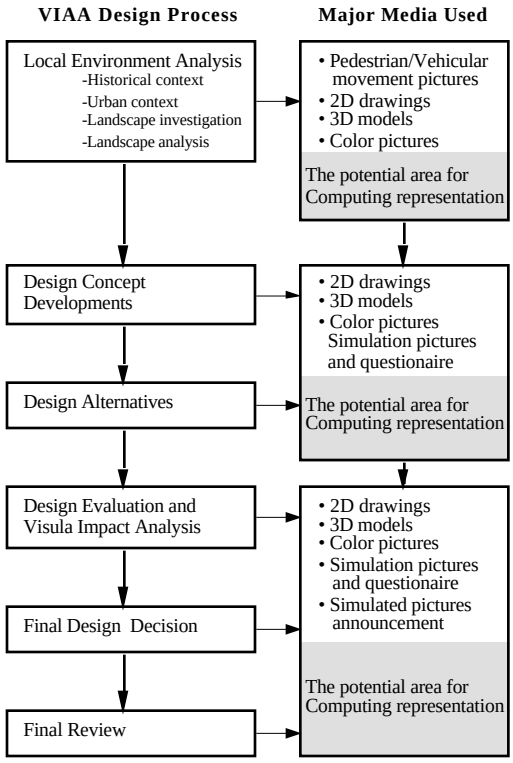



*Figure 2.* VIAA design process and corresponding media.

## 3. Empirical experiments

We conducted an experiment to try to understand more the advantage and shortcoming for the traditional 2d and 3d representing media and computing media to be used in the VIAA design process. We adopted the six most influential factors included in Rahman's checklist above—topography, materials/color/texture, projection/proportion, solar glare, artificial lighting, and approaching movement—specifically for the *VIAA*; and we also added another six most important factors—site relation, adjacency, orientation, natural lighting, circulation, and the sense of space—specifically for the *design process.* The twelve factors together construct the variables to test for understanding the *effective values* for different representing media in the VIAA design process. Note that all other factors in both the VIAA and design process should be further included to propose a better, in-depth realization. Ten subjects were chosen. Their ages range from 22-40 and their education levels range from high school to graduate school. Because this study focuses first on the use of different representing media in the VIAA design process for the communication between designs and clients/habitants in the urban project, the ten subjects were all selected from clients and habitants without any design professional background. Please also note that further study for subjects with professional background is needed.

We provided three groups of representing media for the same project:

- *computing media* including image processing/synthesis, 3d modeling/rendering, animation, and VR,
- *physical models*, and
- *2d drawings* including plans, elevations, sections, perspectives.

Before the formal experiment, we demonstrated and explained the meanings of the twelve factors as a necessary warm-up period for non-professional subjects. For each subject in the experiment, we followed three steps for the three groups of media respectively. In each step, we first shown them different combination of the media carefully and then asked them to mark the effective value ranging from 1 to 5 for the factors mentioned above.

The result shows that the computing media are very appropriate for capturing some factors such as approaching movement, artificial lighting, solar glare, projection/proportion, material/color/texture, and topography. Subjects also reported that the 3d physical models are good for representing site relation, adjacency, orientation, and natural lighting. However, the empirical data also illiterates that the 2d drawings are easier to comprehend than the computing media for the categories of adjacency, orientation, natural lighting. The result is summarized in Figure 3. It generally shows that clients and habitants can understand design idea better through

computing media and physical models; however, the statistics for professional designers need further research as mentioned previously.

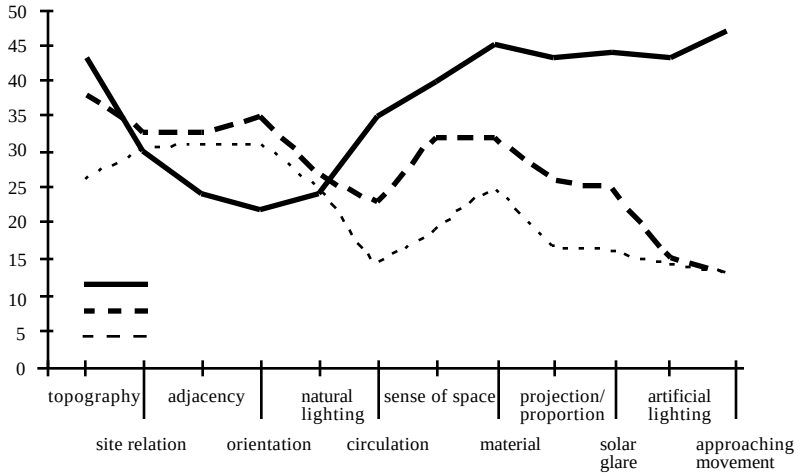



*Figure 3.* The experimental result.

## 4. Revisions and validations from a real project

The experimental result conducted in the laboratory can be considered to fill in the shaded areas in the VIAA design process shown in Figure 2, to finalize the entire procedure. For example, in the local environment analysis, digital models, animation, and VR can provide important assistance thanks to their strength on approaching movement, artificial lighting, the sense of space, and topography. In the stages of design concept developments and design alternatives, image processing/synthesis, 2d rendered drawings, and 3d modeling/rendering should be able to play critical roles in addition to other traditional media. And, all the computing media especially detailed VR can benefit the latter stages including design evaluation and visual impact analysis, final design decision, and final review. This logical expectation is expressed as shown in Figure 7.

However, we all know well the limitation of the laboratory data. In order to pursue better validation and some necessary revisions for the objective of this paper and to apply to real-world urban projects, the above logical expectation for the computerized VIAA design process is further discussed and tested in the real-world urban design project chaired by the second author—The design of the Eastern Gate Plaza in the city of Hsinchu, Taiwan. The Eastern Gate Plaza has long been the geographical, historical, cultural,

and economical center of the city Hsinchu, a three-hundred-year-old city in the northern Taiwan. The gate building, recognized as a second-class historical heritage as well as the most important city landmark, is erected in the plaza. The mission of the real-world project is to use computing media in the VIAA design process in order to re-design the plaza. This project was conducted from 1996 to 1998, dividing into two major phases—design concept/guideline formation and design competition. The first phase, September 1996 to August 1997, followed the VIAA design process in association with the experimental results of computing media mentioned in the above section to propose several design concepts and guidelines. In the second phase, September 1997 to January 1998, nine architectural firms in Taiwan joined the competition which was based strictly on the design concepts and guidelines.

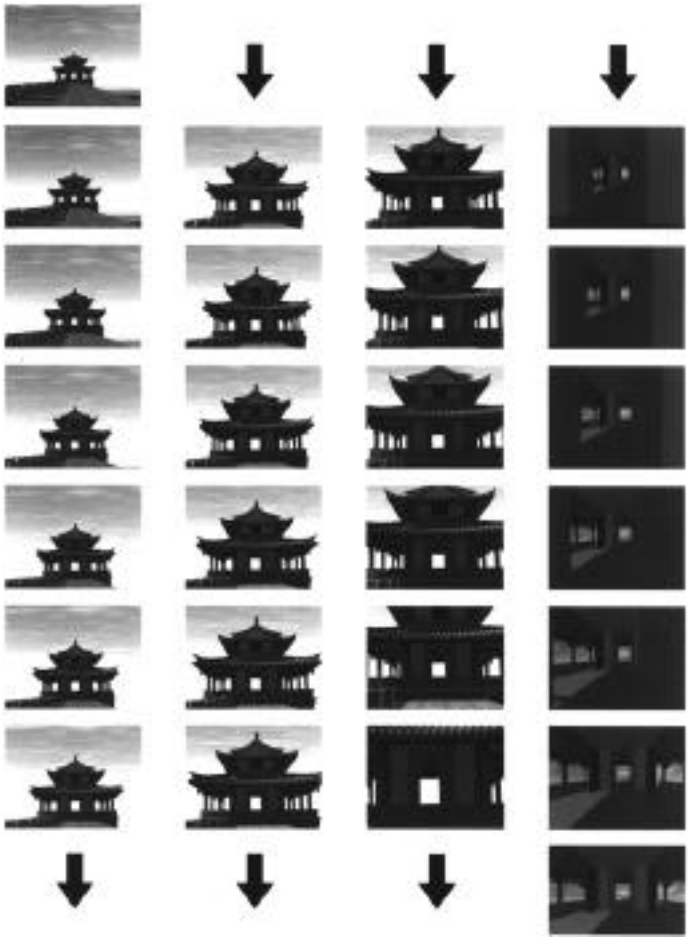


*Figure 4.* An animation presenting the spatial and lighting experience.

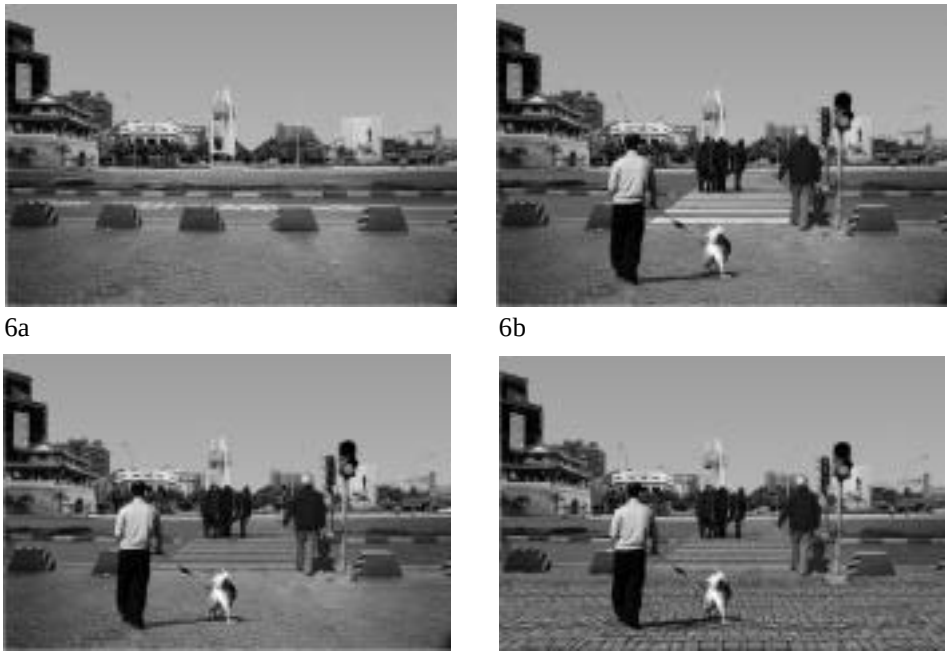
In the early stage of the first phase, that is the local environment analysis, a computer model for the plaza and gate building was first constructed. We then generated three episodes of animation with respect to the computer model—the urban/historical context, the traditional Chinese construction process, and the spatial and lighting experience (Figure 4)—in order to present in-depth ideas for urban/historical context and site/landscape analysis. Finally a QuickTime VR demonstration (Figure 5) was presented to the city government officials, habitants, and some licensed architects.


*Figure 5.* A QuickTime VR demonstration for the Plaza and the gate building.

In the middle stages of the first phase, namely design concept developments and design alternatives, a great number amount of image simulations were produced to demonstrate various crucial design concepts in addition to the computer model presentation already used previously. For example, in order to illustrate the circulation and material/color/texture of the plaza access as shown in Figure 6, we produced four images to convey different concepts and alternatives to government officials, habitants, architects. Image simulations of this kind were also greatly used to express our concepts on artificial lighting, solar glare, plantation (tree height in relation to the gate building), landscaping, view obstruction, topography.

The latter stages of the first phase involved all the computing media to reach many concrete design concepts and guidelines. Please note that the computing media included in all stages were presented directly to government officials, Hsinchu habitants, and architects in several public hearings and symposiums. These computing media were used coupled with all kinds of 2d drawings and various physical models in all stages. When we

reached the final decision for design concepts and alternatives in the first phase, all the presentation produced by computing media and traditional media guided the design developments for the nine design firms that joined the competition in the second phase.



6a 6b

6c 6d

*Figure 6.* Image synthesis for the guideline regarding access materials: a. the current situation, b. a normal access, c. the access using the same material as the base of the gate building, d. the use of the same material extends to the surrounding sidewalk.

The competition was judged by a group of jury who studied the project references through the computing media and traditional media used in the first phase. The Plaza is now under construction and expected to complete by the end of 1998. The entire project including the computerized VIAA urban design project and the competition guided by computing media is regarded the most successful project ever since in Hsinchu through more than a hundred reports on the newspapers. Many of the image simulations, 3d models, and episodes in animation used to be illustrated in the press. The result of this computerized process is also regarded one of the most successful project in Taiwan through the publication of a special issue on the *Architects* magazine, the largest professional magazine in Taiwan.

## 5. Concluding remarks and further studies

The main objective of this research is to propose a computerized VIAA design process for urban projects. A final process is illustrated in Figure 7 based on the validating findings from both the laboratory experiment and the real-world project mentioned above. In the computerized VIAA design process, several features can be concluded:

- 3d modeling/rendering is very helpful for the understanding of the design issues, concepts, and developments in both the early and final stages.
- image processing/synthesis is important in the middle stages to consider and compare different alternatives.
- VR, although its capacity is still very limited in PC-level computers, is also very effective in both the early and final stages.

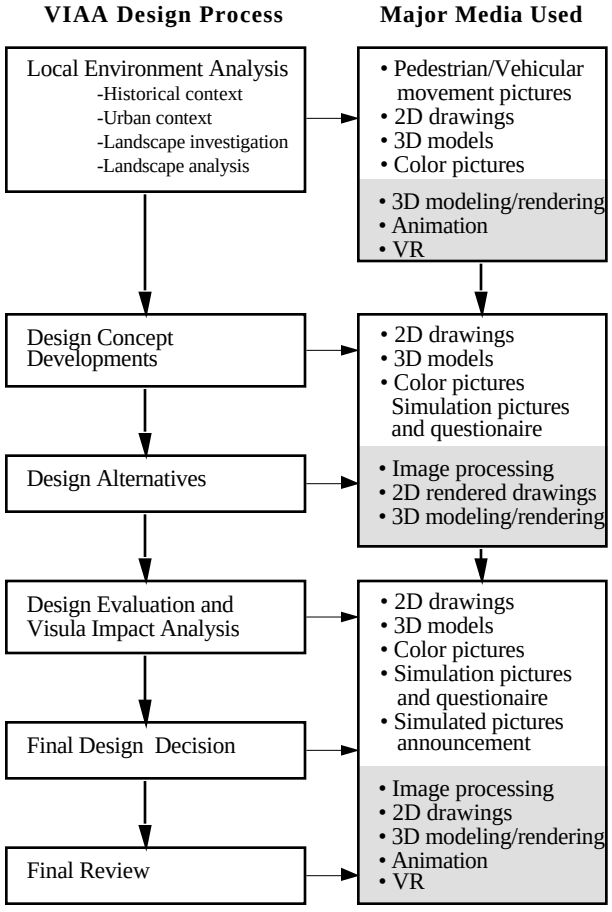



*Figure 7.* A computerized VIAA design process for urban projects.

There are many serious limitations in this research although we report some points of view. In the experiment, more subjects especially subjects with professional training should be included to provide sound empirical understanding not only for clients/users but also for designers. All other factors in the VIAA checklist and general design processes, which were not involved in this experiment, need further study. In the real-word project, all the examined factors and all the available computer media should be investigated more systematically and profoundly. The relations between different computing media as well as between computing media and traditional media remain unknown. A much more powerful workstation-based VR simulation should be involved to gain real-time response and experience of design.

These limitations form the future studies of this research and the major goals for the continuing project of the Eastern Gate Plaza—the riverside area of the Hsinchu Moat connecting to the Eastern Gate Plaza.

## Acknowledgments

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