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The Hsinchu experience: a computerized procedure for visual impact analysis and assessment

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Abstract

This paper examines the procedure of visual impact analysis and assessment (VIAA) proposed by Rahman and reviews the use of computer-aided design (CAD) applications in urban projects in the real world. A preliminary computerized procedure for VIAA is proposed. An experiment 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 Hsinchu, Taiwan from 1996 to 1998. Based on the face-to-face discussions with Hsinchu habitants, government officials, and professional designers, a final computerized procedure for VIAA is concluded.

Keywords: Computing media; Design process; Computer-aided design

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 [1,2], 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 [3–5]. 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 (VIAA) in urban spaces [6]. This study thus intends to provide a new, computerized procedure for VIAA based on current developments of the use of image processing/synthesis, 3D modeling, multimedia, animation, and the newly developing virtual reality (VR) technology.

This paper begins with reexamining the procedure of VIAA proposed by Rahman [6] and reviewing the use of CAD applications in urban projects in the real world. A preliminary computerized procedure for VIAA 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 modeling, multimedia, animation, and VR in different stages. An experiment was conducted in our laboratory to verify the preliminary procedure mentioned above. Professional designers and nonexperienced city habitants were selected as subjects in the two experiments, respectively. Based

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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 Hsinchu, Taiwan from 1996 to 1997. Based on the face-to-face discussions with Hsinchu habitants, government officials, and professional designers, a final computerized procedure for VIAA is then concluded.

2. Background on VIAA

What kinds of and how many design factors should be involved in the procedure of VIAA, especially those applicable to urban projects, have been widely discussed [7–9]. Rahman [6] proposes a checklist of design and visual criteria attempting to come up with a generalized procedure for VIAA as shown in Fig. 1.

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) 3D composition: general form, articulation, skyline, height, transition, projection;
(c) elevational composition (2D): overall style, rhythm, color, materials, details, texture;
(d) viewing conditions: solar glare, artificial lighting, view obstruction.

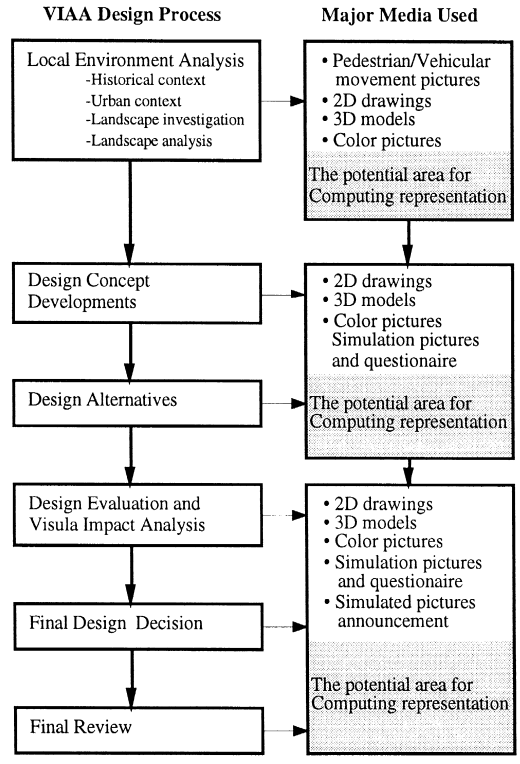

Fig. 2. VIAA design process and corresponding media.

In addition to suggesting the use of traditional media to use in the VIAA design process, Rahman [6] also mentions the importance of computing media, including 3D modeling and animation (Fig. 2).

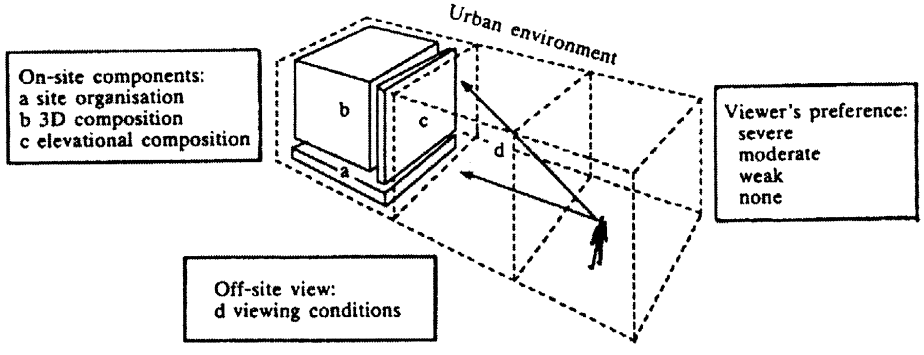

Fig. 1. Analysis of the external physical features of any project in relation to the percipient (after Rahman [6]).

Because various computing media have been effectively used on different stages of the design process [2,4,5], computing media involving image processing/synthesis, 3D modeling, multimedia, animation, and VR can play a more important role during the VIAA design process as the shaded areas shown in Fig. 2.

3. Empirical experiments

We conducted an experiment in the hope to understand more advantages and shortcomings 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. We also added another six 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 be tested 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 included to propose a better, in-depth realization. Ten subjects were chosen. Their ages range from 22 to 40 and their education levels range from high school to graduate school. Because this study focuses on the use of different representing media in the VIAA design process for the communication between designers and clients/habitants in the urban project, the 10 subjects were all selected from clients and habitants without any design professional background. We would like to mention in passing 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.

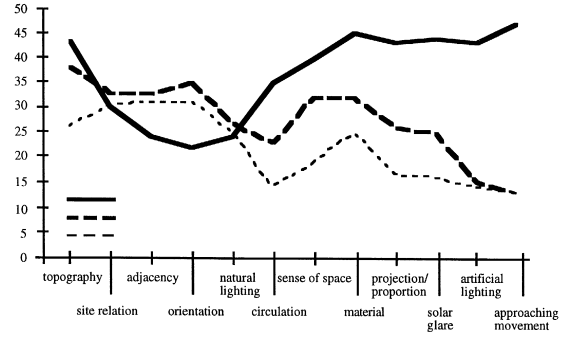

Fig. 3. The experimental result.

Before the formal experiment, in the warm-up session, we demonstrated and explained the meanings of the 12 factors to these nonprofessional subjects. For each subject in the experiment, we followed three steps for the three groups of media, respectively. In each step, we first showed 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 reveals 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 Fig. 3. It generally points to the direction 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.

4. Revisions and validations from a real-world project

To finalize the entire procedure, the result of the laboratory experiment can be considered to fill in the shaded areas in the VIAA design process shown in Fig. 2. For example, in the local environment analysis, digital models, animation, and VR provide im-

portant 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 seem to play critical roles as other traditional media. In addition, all the computing media, especially detailed VR, could benefit the latter stages including design evaluation and visual impact analysis, final design decision, and final review. This logical expectation is shown in Fig. 8.

However, from previous studies, we have learned the limitations of the laboratory data. Therefore, in order to pursue better validation and some necessary revisions for the objective of this, the above logical expectation for the computerized VIAA design process is further tested in the real-world urban design project chaired by the first 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 Hsinchu, a 300-year-old city in 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 redesign 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

施政規劃得宜 可節約公帑

交大教授盼地方建設應顧及文化背景 避免建了又拆窮折騰

【記者潘國正新竹報導】交大教授劉育東五日表示，政府有經費進行建設，如果建設之前的規劃沒有考慮當地文化和歷史的背景，就必須付出更多的經費，改善不當的建設，而目前正處於這種情境。他以電腦動畫模擬出東門城的景致，讓與會者產生新的視覺經驗。

接受文化中心委託對竹塹地區文化資源進行調查研究的劉育東教授，昨天提出期末報告，報告中說明新竹市從平埔族原住民到現在，留下許多豐富的文化和歷史資源，而且都存在於我們生活的空間內。

從日據時代的都市計畫圖可以看到，他們實施都市計畫時，儘可能的尊重當時的文化和歷史建築和資源。他說，文化和歷史空間不是全部都要保留，爲了都市機能的發展必然有所取捨。從一九〇五年的都市計畫圖中，還可以看到東門、西門和北門三個城樓，及放射狀的圓環，這雖然是都市發展據點，但卻不利於交通紓解，因此陸續拆除，但還保留了東門城，而且劃爲古蹟。

進入國民政府後，早期的都市計畫劃者，多半沒有到各縣市進行深度的了解，導致許多規劃都不尊重都市發展的歷史脈絡和文化資產，因而出現道路穿過重要歷史空間的規劃。

更讓人惋惜的是，後來的政府的建設，都沒有關照文化歷史的發展，把許多經費建築在不該建的空間內，不僅沒有讓原來的景觀更好看，反而造成視覺污染和破壞。因此後面的人還必須花錢去拆除這些建設，例如新竹火車站正立面的電子鐘，以及東門城前的鐘塔和銅像等。

他整理出新竹市清朝時代和日據時代現存的文化資產和建築空間，這些空間可以用「減法」的方式去除不必要的建築，讓原建築物呈現原來的風貌。同時可以用電腦模擬的方式，讓規劃者和民眾事先了解改善後的景觀，讓施政決策更精確，獲得支持。他並放映電腦模擬的東門城四周景觀，與會人士從中獲得新的視覺視野。

財政科長陳國棟首先表示，這場報告都市計畫和工務單位都應該全程參加，以了解新竹市的發展過程，同時也可以了解工程建設的規劃構想。他對電影模擬出來的效果感到驚奇，認爲這是提供規劃者和民眾最好的方式，應該廣爲流傳。

他說，麗池公園枕頭山（二號）公園有十七公頃土地，即將發包，這裡有豐富的文化和歷史資源，如自治會館、動物園、孔廟等。同時也有多元的休閒空間，如室內外的體育館、兒童樂園、麗池公園等。如果能先透過電腦模擬出來，規劃單位可以更精確的了解各項機能和效果。

文化中心主任洪惠冠表示，新竹市有豐富的文化資源，都是民眾的財產，只需要有系統的整理和規劃，就可以呈現出有特色的風貌，希望各界能共同參與。

東門夜色 落成於道光九年（一八二九）的新竹城，目前只剩下東門迎曦城樓。交通大學應用藝術研究所教授劉育東，帶著研究生考據出新竹城的建築風格和歷史，用電腦模擬出現有的東門城與城牆的景致，同時也以白天和夜晚相比較，讓人發思古之幽情。（圖文：潘國正）

Fig. 4. An episode of the animation, reported on China Times, presenting the spatial and lightning experience.

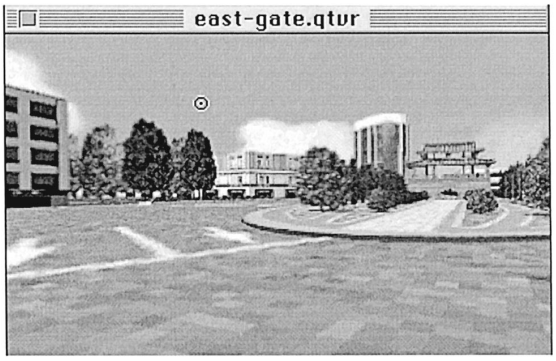

Fig. 5. A QuickTime VR demonstration for the Plaza and the gate building.

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 that was based strictly on the design concepts and guidelines developed in the first phase of the project.

In the early stage of the first phase, i.e., 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 (Fig. 4) — to present in-depth ideas for urban/historical context and site/landscape analysis. Finally, a QuickTime VR demonstration (Fig. 5) was presented to the city government officials, habitants, and some licensed architects.

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 Fig. 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

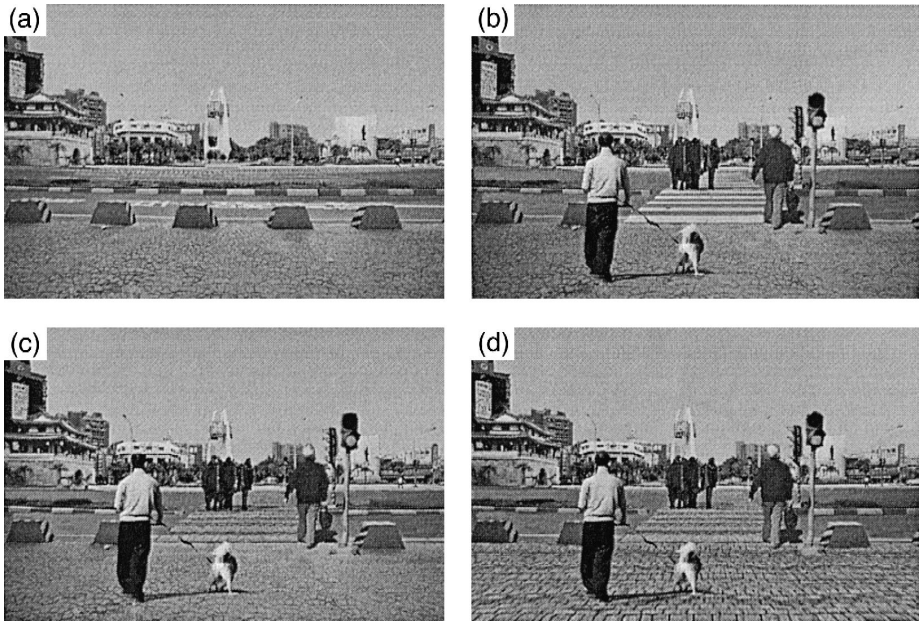

Fig. 6. Image synthesis for the guideline regarding access materials: (a) the current situation, (b) a normal class, (c) the access using the same material as the base of the gate building, (d) the use of the same material extends to the surrounding sidewalk.

to express our concepts on artificial lighting, solar glare, plantation (tree height in relation to the gate building), landscaping, view obstruction, and 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 with all kinds of 2D drawings and various physical models at all stages. When we reached the final decision for design concepts and alternatives in the first phase, all the presentations produced by computing media and traditional media were provided to the nine design firms that joined the competition in the second phase to be used as the guide of their design development.

The competition was finally judged by a group of jury who studied the project references via the computing media and traditional media used in the first phase. At present, the Plaza is now under construction and expected to be completed by the end of September 1999 (Fig. 7). 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 by more than a hundred reports on the newspapers. Many of the image simulations, 3D models, and episodes in animation were used as illustrations in the press. The result of this computerized process is also reported as one of the most successful projects in Taiwan in 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 Fig. 8 based on the validating findings from both the laboratory experiment and the real-world project mentioned above. To conclude, the computerized VIAA design process has several features:

- 3D modeling/rendering is very helpful for the understanding of the design issues, concepts, and developments at both the early and final stages.

Fig. 7. The Plaza which is under construction and expected to be completed by the end of September, 1999 (photo by Jia-Chen Lin).

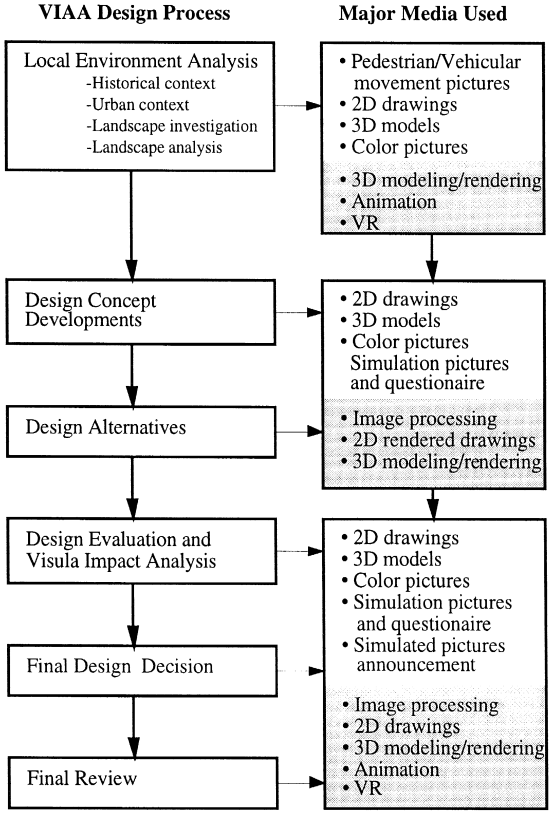

Fig. 8. A computerized VIAA design process for urban projects.

- Image processing/synthesis is important in the middle stages to 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.

However, this research still has many serious limitations. For example, more subjects, especially subjects with professional training, should be recruited in the experiment to provide deeper empirical understanding. In further studies, all other factors in the VIAA checklist and general design processes, which were not included in this experiment, should be also considered. In the real-world project, all the factors examined and all the available computer media should be investigated more systematically and profoundly.

In addition, the relations between different computing media as well as between computing 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.

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