MODELS, SCANNERS, PENCILS, AND CAD:
interactions between manual and digital media

by

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ABSTRACT

This paper discusses new approaches to the relation between handmade and computer aided media in design. The discussion focuses on two advanced studio projects in which graduate student designers incorporated interactions between physical models, a digital scanner, handmade drawings, and the manipulation of images in the computer. These interactions provide a valuable supplement to traditional means — both manual and digital — for generating, developing, and representing architectural form. Features of the student's work that other designers will find significant are its focus on multiple interactions, its setting within a realistic design process, and its use of low levels of computer technology. After describing details of the designer's media techniques, the paper discusses the practical and theoretical implications of the work.

Introduction

Recent experiments have opened new ways for designers to use interactions between handmade and digital media. [Herbert, 1994]. Following the lead of these experiments, two student designers have applied media interactions in advanced studio projects. The students, Jason Roberts and Francis Dardis, for whom I am a faculty advisor, are master's degree candidates in the Department of Architecture at the University of Oregon. Their work on media interactions was the subject of a special studies course taken in parallel with their normal terminal studio projects.

Significance For Design

Three features of this work are significant for other designers: its focus on multiple interactions, its setting within a realistic design process, and its reliance on relatively low level of computing technology. I will outline these features briefly before describing how media interactions can be applied in the design studio.

The first significant feature of this work has to do with its focus on multiple rather than single interactions. In computer-aided design, most interactions between handmade and digital media are simple and single, that is, one-time, one-way changes in which the designer shifts some substantial part of the design process from a manual to a digital medium, or vice versa [McLeod, 1995; Fargas, 1993]. For example, a shift in one direction would be at the end of the conceptual stage when a designer might copy handmade conceptual sketches into a CAD program for detailed development [Novitsky, 1994]. Or, for a shift in the opposite direction, after making 3D massing studies with a computer modeling program, a designer might generate an underlay perspective print for final rendering by hand [Danahy, 1989]. In either case, one-time, one-way shifts close out a unit of work altogether from one medium and open it up altogether into the other: manual to digital, or digital to manual. In contrast, the work described here focuses not on closing out one medium and opening up the other, but on keeping both manual and digital open and in interaction, especially with feedbacks through multiple iterations. These multiple interactions provide a supplementary approach that is qualitatively different from to one-time, one-way shifts.

The second feature of the work, its setting within a realistic design process, is significant because it provides a measure of the effectiveness of manual and digital interactions. Preliminary research and experiment, such as preceded this work, are necessary but not sufficient steps in developing new approaches and techniques for design. The preliminary steps must be followed by realistic applications that give designers a sense of what outcomes they might expect from using a new technique. The applications described below — in final thesis projects developed through two terms of advanced studios by graduate designers who are candidates for a second professional degree — are about as realistic as applications can get within an academic setting. Their processes and results seem readily adaptable to professional practice. Thus these applications represent a fair measure of the effectiveness of multiple interactions between manual and digital media in the schematic and developmental phases of design .

A final significant feature of this work — in common with the techniques described in "Database Revisited" (Week, 1995), elsewhere in this volume — is its reliance on easily accessible everyday technology. With only commonplace hardware and software such as a color scanner, a color image editing program, and a color printer, a designer can begin using these techniques at once. Although the technology is easily accessible, managing multiple interactions between manual and digital media is not necessarily easy to do; it requires as much acquired skill as managing other design media.

Taken together, these features comprise an effective, practical, and economical set of design procedures. Multiple interactions between manual and digital media provide a valuable complement to traditional means — both manual and digital — for generating, developing, and representing architectural form. Moreover, introducing media interactions does not necessarily displace program, context, and construction technology as potential sources for form in design. Roberts and Dardis, for example, relied on more than just the effects of media interactions for their work. They also conducted studies of program, physical context, precedent, history, and construction technology such as are expected of students in advanced studios. Nevertheless, the media interactions these designers used did provide them with opportunities to explore new approaches to form, as will be apparent from the description, below, of their working methods.

Project #1: Pietro Belluschi Center for Portland Architecture and Urbanism, by Jason Roberts.

This project involved a complex building on a quarter-block site in downtown Portland. The site included a small existing 3 story masonry structure. The program called for a mixture of educational, social, and office spaces, as well as a fabrication shop and support facilities.

Roberts's handmade media included pencil and mixed media drawings on tracing paper, cardboard study models, and fragments of model parts. He also used color and black and white photographs. His digital media included an Apple Color Scanner, a

Macintosh 8100 with Adobe Photoshop 2.5, and a Tektronix Phaser III color printer. Color played an important role in the interactions, so the black and white illustrations in this paper do not fully describe the images with which Roberts worked. Throughout most of the work he used handmade drawings as the leading medium. Typically, he scanned handmade media (i.e., both drawings and models)into the computer as a basis for image editing and then printed out the edited images as a basis for further work in traditional hand media. Because these efforts were fed back through multiple iterations as circumstances suggested, interactions between manual and digital media were an essential feature of the design process. The following 3 examples show how the interactions Roberts used opened up new approaches to studying architectural form:

In the first example, Roberts studied facade development through interactions between the computer and a physical model. Earlier he had made a series of preliminary sketch probes and diagrams by hand and built a rough study model of paper and cardboard [figure 1a]. He laid the faces of this model, one by one, directly on the glass platen of the scanner and brought the resulting images, as 'elevations', into the computer's image editing program. He selected the west elevation as a principal focus for study, and, to provide a desktop of related references and tools he also scanned in an organizational diagram, a scale, and other drawings for a total of 11 windows [figure 1b]. One of these windows held a 'palette' of model building materials [figure 1b, and c (left)]. This palette included scanned images of such materials as pieces of metal screen and textured board, photographs of building materials such as brick and glass, a scale, and photographs of building components such as windows; other material were used for later developments [figure 1c (right)]. Roberts cut, pasted, stretched, and resized selected parts of the materials palette to develop the sleeted image as an elevation, adding color and textures. He also passed parts of the elevations and items from the palette through the editing program's filters to introduce computer-generated artifacts and 'create' new materials. These manipulations provided a realistic sense of surfaces, articulation, and solid-void relationships reflecting Roberts's current understanding of program and context issues, and they enabled him to explore more possibilities more quickly than would have been feasible with equivalent alterations of the physical model. As he worked he saved copies of particular parts of the evolving model, and thereby assembled a library of elements for studying alternative compositions. When these manipulations produced promising results [figure 1d], Roberts printed them out and used them as a basis for new physical models and other manual drawings.

Another example illustrates a variation of the first, combining handmade drawings as well as a physical model as subjects for scanning into the computer. Roberts made pencil section drawings and a physical section model especially for study in the computer. This was a cardboard study model of a section of the building [figure 2a], including provisions for a portion of the building that was assumed to be open to the sky. Laying the section face of the model on the scanner glass, he directed the light of a drafting lamp into the sky opening and then scanned the resulting light patterns [figure 2b]. The scanned image not only made it possible to observe the resulting light patterns — otherwise difficult in small models — but also to use the image editing program to manipulate the light effects as a basis for making adjustments to that feature of the model. Rather than modifying the model directly, Roberts made a new scaled section drawing by hand and laid it over the scanned image of the sectional model [figure 2c]. Again, this image was the basis for subsequent models and drawings made by hand.

A final example of manual to digital interactions involved scanning 3 section drawings into the editing program to form a composite section drawing [figure 3a]. Onto this composite section, Roberts overlaid surfaces from his palette of model-building materials [figure 1c] to build up an east elevation [figure 3b] and variations of it [figure 3c]. By controlling the transparency of the overlaid materials, he could retain some of the underlying section drawings to give a sense of interior depth to the evolving elevation. By this means he developed the first conception for this elevation in the computer rather than by handmade media; no handmade versions existed.

Roberts's final presentation for the project included color printouts from the image editing program such as an elevation, along with progressively enlarged details [figure 4a]. He also made a finished physical model [figure 4b].

Reviewing this work, Roberts has noted first that interactions between manual and digital media have forced him to take new approaches to issues of program, context, and technology. Using both media helps to avoid his getting trapped by the habitual assumptions that necessarily accompany either medium separately. Second, he has found the computer's potential for introducing graphic artifacts to be a valuable feature because it forces reinterpretation of accepted images. And third, this way of working offers practical advantages in that computer collages and composites allow him to generate better ideas for particular parts of the project and to study them more quickly into development and final representations than would have been possible with either medium alone.

Project #2: A Forest Research Institute, by Francis Dardis.

Unlike the urban location of the previous example, the site for this project was at the edge of a small town in a mountain valley, was bounded by a railroad line and a stream, and included the ruins of a burned-out lumber mill. The program requirements listed research laboratories and shops, maintenance facilities and equipment yards, office and administrative spaces, an interpretive center, and residential units. Thus the project involved large-scale site planning issues and, implicitly, a multiple-building complex with many open spaces.

Dardis's handmade media, like Roberts's, also included pencil drawings and models, his computer hardware and software were the same, and color played an important role in the work. But Dardis used a different approach to models: because he had had a previous studio's experience in scanning objects as a basis for design, he was able to design several generations of models specifically for this purpose. He had no single lead medium; he used the handmade models, drawings, and computer images as circumstances suggested. He arrived at an tangled sequence of interactions between handmade and computer processes, however, as the following examples will show.

Early in the schematic stage of the work, Dardis made an abstract physical model of the site expressly as a source for image manipulation. Materials for this model were translucent plastic and reflective Mylar [figure 5a], which Dardis knew to produce strong scanned images . Editing the scanned results [figure 5b] produced new images [figure 5c] that, at the time, led nowhere, so he returned to handmade media. In charcoal he drew a series of large interpretive sketches of what might be the character of buildings on the site [figure 6], and several freehand site plan studies of potential building locations (not shown here). He scanned these site plans into the computer — again with no apparent progress, but recognized the possibility that circulation paths might furnish a key to the overall organization of the project. He returned to model building, this time making an abstract diagrammatic construction of access and on-site circulation paths [figure 7a]. This model was constructed of wood and metal strips that Dardis thought would offer effective contrasts and shadows for scanning [figure 7b]. After editing the initial image from the scanner through several graphic filters [figure 7c], he found shapes that recalled his earlier charcoal sketch [figure 6] and opened the way to more freehand sketch plans and a new study model that organized buildings on the site within a revised circulation scheme [figure 7d].

In a radical change of focus, Dardis made a 1/2" scale model of a bench intended as a example of wood lattice and bracing [figure 8a]. He scanned this model [figure 8b], manipulated the resulting image, rescaled and replicated it to suggest forms for whole buildings [figure 8c, d] and launch another round of manipulations. A new version of the site model and studies for individual buildings followed. Another abstract model [figure 9a] on the scanner glass produced an image which, when inverted, gave strong suggestion of depth [figure 9b] as a source for further manipulations[figure 9c, d] and for constructing a physical model [figure 10a]. Dardis's final presentation included a 3d computer model in AutoCAD [figure 10b], and a printout of this model rendered with images from a palette of scanned photographs of wood textures [figure 10c].

Dardis has observed that these interactions made a valuable contribution to his design process. First, manipulating images in the computer is a very efficient way to generate elevation studies. He found that he could explore many alternatives in graphic detail at low cost in time. Second, his return to early images suggests that these interactions introduce more non-linear jumps than processes that are conducted with only one medium. Third, the generative feature of the interactions seems to follow the transition from 3D models to 2D images and vice versa; the scanner and computer facilitate the change and make it more efficient than such transitions could be with handmade media. And fourth, scanning drawings and models into the image editing program offers a valuable benefit by allowing the designer a way to explore, or play, with elements of the problem in complex detail without the large amount of redrawing that handmade media would require; he found this activity especially useful to get out of being "stuck" at some point in the process.

COMPARISON

Similarities in Roberts's and Dardis's approach suggest additional comments focused on particulars of their work. It is significant, for example, that Roberts and Dardis did most of their handmade drawings in line, but developed the computer images in terms of surfaces. Other writers have observed that in a pencil culture designers think of planes and volumes as defined by edges, but that the computer could make it easier for designers to think about their work in the same terms as they see the world — that is, in terms of surfaces rather than edges [Brown and Novitsky 1989]. Current 3D modeling programs typically make extensive use of lines-for-edges for wireframe, hidden line and shading views, however, so it appears that the imaging techniques described in these student's work can complement the linear bias of such modeling programs as well as that of handmade drawings. The relationship of lines and surfaces also has theoretical implications discussed in the concluding section of this paper. Another similarity in these projects is a lack of symmetry evident in the designer's media interactions, especially in their early generative processes: Roberts and Dardis did not treat the products of handmade and digital media equally. They did more deliberate manipulation of handmade images in the computer than the reverse: they did little manipulation of computer images by hand. For example, in handmade media, the equivalent of their editing images in the computer would be for them to edit printouts by drawing on them by hand, or by cutting and folding the printouts to make physical models, or to cut and paste surfaces from a printout onto a physical model.

In both projects, then, the student designers noted that interactions between media facilitate the work, making it possible to explore more alternatives in richer detail than either handmade media or computer-aided modeling programs alone would permit. Furthermore, in both projects the designers did a substantial part of their synthesis on the computer screen — not in the prints reproduced here with reduced size and missing color. And both projects show that image editing offers a fast and effective alternative to ray tracing programs for realistic final rendering of architectural subjects.

The techniques that these two students used are far from exhausting the possibilities of media interactions, however. There are practical and theoretical implications of this genre that deserve mention here.

Practical Implications

I will leave theoretical matters for the close of this paper and turn here to practical implications. As Aristotle might have said if he had thought of it, practical implications are of 3 kinds: short term, medium term, and long term.

In addition to the short term implications mentioned above regarding the potential for more manual manipulation of computer printouts, new developments in image editing software seem directly applicable interactive media in design. The recent introduction of layers and object-oriented functions in Adobe Photoshop, for example, seem especially appropriate for use in architectural design. Layers would add the flexibility of separately editing the various elements of the composite plans and elevations Roberts used in his work, and object-oriented capability would help Dardis pursue extrapolations of elements such as the lattice/bracing model. Likewise, both of the students might have benefitted from the UpFront program's ability to apply 2D images to surfaces of 3D computer models [Anderson, 1992].

Another class of short term [and mid term] applications appears through connection to companion papers in this volume, i.e., those on "The Database Revisited," and "Drawing Analogies" [Do and Gross, 1995]. It would be possible, for example to bring the basic idea of the “Drawing Analogies” program into play immediately for the processes described above: Roberts and Dardis could, by ordinary search methods, locate printed or solid images from external sources — that is, sources outside the immediate design task — scan these images into the editing program and treat them just as they have treated the images derived from inside the design task. Furthermore, the functions described in the “Drawing Analogies” paper, when fully developed in the mid term, would make access to such images broader, deeper, and faster than ordinary search methods and would thus support more effective use of media interactions in design. Similarly, designers using the techniques for manual to digital interactions described in this paper could scan in images and text from pattern language sources, on which the “Database Revisited” program rests, and incorporate them in the evolving design. And similarly, when fully developed in the midterm, the functions described in that paper would provide better and faster access to more patterns than would ordinary library search methods.

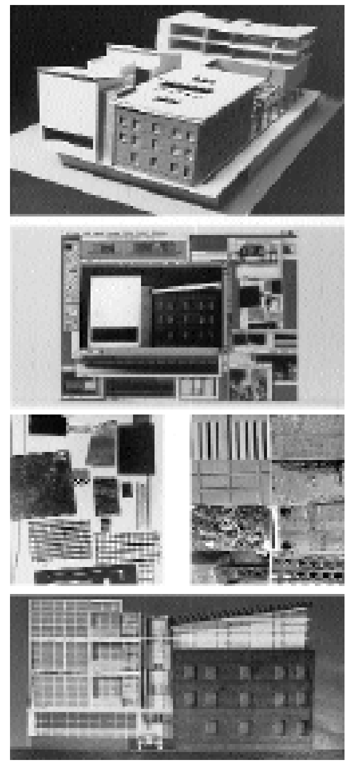

Figure 1:
(a) physical study model;
(b) computer screen with scanned image of model and accessory windows
(c) palettes of scanned materials
(d) completed draft of west elevation.

Extension from these short and mid term applications can suggest other, more speculative, notions for the long term. The possibility of combining techniques described in this paper for manual and digital interactions with those of “Drawing Analogies” and “Database Revisited” can be extended to include other databases such as art history, cinema, advertising, photo-journalism, and . . . science [Herbert, 1993, 123].

Another long range conjecture proceeds from the practice of importing and exporting files from one application program to another. Such operations call into question the basic relation of project files to application programs. Indeed, Kevin Matthews has suggested that moving project files from one application program to another (or trying to incorporate an assortment of token functions under one umbrella program) is backwards — that it might make more sense to bring functional modules from advanced application programs to the project files [Matthews, 1994]. For example, in projects like those of Roberts and Dardis projects, a preliminary 3D project file might be established, an image from the pattern language database might be brought in, that image treated by the filtering functions of the image editing program, and the result built in to the evolving computer model. These speculations on long term applications will serve to introduce the theoretical discussion below.

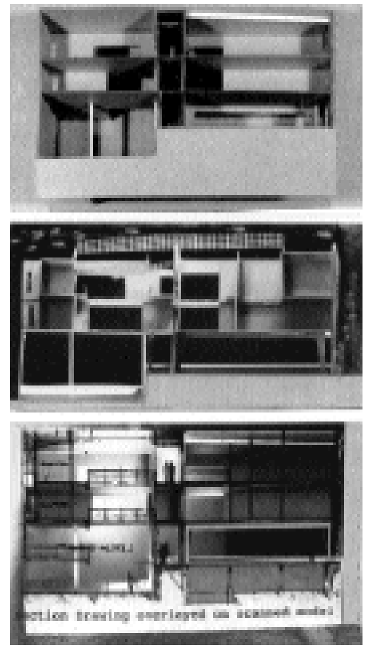

Figure 2:
(a) physical study model of section;
(b) scanned image of model with simulated light from sky;
(c) scanned image edited and overlaid with section drawing.

THEORETICAL IMPLICATIONS

Turning from practical to theoretical implications provides another view of manual to digital interactions. To focus first on a particular issue, Dardis's observations about the productivity of transitions between 2D and 3D, and vice versa, deserve further study. If analysis of the work of other designers working on other projects confirms that such transitions are especially creative moments within the design process, then some the basic assumptions about computer-aided design are subject to challenge. For example, one assumption is that because buildings exist in 3D, the designer's work will be most effective if it is also in 3D. Another assumption is that when the designer does work in 2D, that translations into 3D can best be done by the computer rather than by the designer. Both assumptions may cause us to neglect important creative links in the working process.

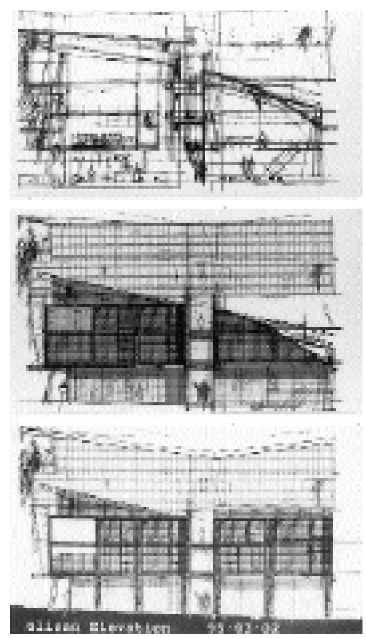

Figure 3:
(a) composite of 3 scanned section drawings;
(b and c) images edited with material from palette to make east elevation.

More generally, the student projects show that the interaction of manual and digital media can open an effective new source for architectural form. These interactions open a new source of form because they make it possible for the designer to complement what I will call 'white' architecture — that is, an essentially colorless architecture based on lines and edges [as noted above], with color and texture assigned only after masses and spaces have been determined. White architecture is an inevitable outcome of most existing computer modeling programs; it is exactly what these programs represent in wireframe, hidden line, and shaded views, and it is implicit in rendering programs that require the designer to assign color and texture information to specified surfaces. With the techniques described in this paper, however, color and tactile values can be used as expressive generators of form, presumably in conjunction with 3D computer modeling, manual drawing, or physical modeling. To explore media interactions that employ color and texture as generators of form is not to displace mass and space from their role as generators, but to supplement or complement their role, to offer designers another set of useful procedures.

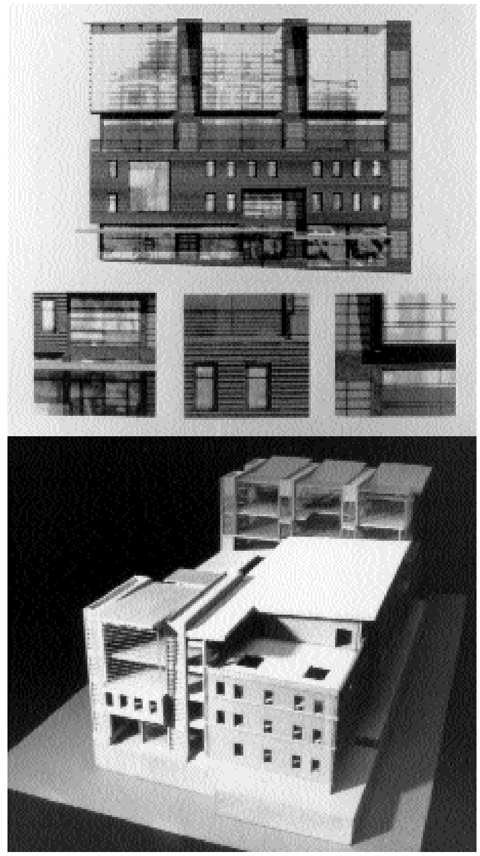

Figure 4:
(a) printouts of east elevation -- compare with figure 3;
(b) west facade of physical model -- compare with figure 1.

Media interactions, like any tools or procedures, are neither neutral nor transparent; they introduce new issues into the work. For example, such interactions confront the designer with uniquely digital artifacts that arise from scanning and image manipulation. These artifacts force the designer to revisit previous interpretations of graphic marks and images, and thus become sources for form. As I have written elsewhere: “[reinterpretations] are the generators of design information and so offer especially powerful sites for influencing design outcomes” [Herbert, 1993, 123]. Of course, the computer is not the only source of artifacts. Handmade media are no less manipulations than are computer operations, and inevitably produce their own artifacts. And handmade media are also no more transparent than those of the computer; they have their own built-in range of graphic strategies and their own peculiarities. Like computer processes, handmade media produce their own effects, which are introduced whether or not the designer acknowledges them. The designer cannot choose to work in a way that media have no effect. Although the designer can decline to formulate an explicit . . . strategy, this default choice does not remove the effects of the medium on the design task, it only removes them from the list of issues for which the designer agrees to be responsible. [Herbert, 1993, 67].

Thus it appears that interactions between handmade and computer media are a complex mixture of the artifacts and the effects introduced by of each of them. If, indeed, such artifacts and effects force the reinterpretations that generate design information, then media interactions amplify the designer’s opportunities.

Does attention to media interactions interfere with traditional architectural concerns? I think the answer is qualified No. Although media strategies and image manipulations have nothing directly to do with such architectural issues as housing costs, construction processes, environmental laws, or weathering, at the end of the day when designers have assembled all the facts and data about these issues and want to begin designing, they must begin making marks in some graphic medium. The problems raised in the interactions between manual and digital media are certainly demanding, and these problems could baffle less experienced students than Roberts ands Dardis and cause them to lose track of traditional concerns. But this situation is not different from any other in which experience is necessary in design. These advanced student's work stands on its own architectural merit. Their work did benefit from their special attention to media interactions. Thus it appears that incorporating deliberate interactions between digital and manual media and manipulating the resulting images as sources for form does not necessarily displace the designer's traditional concern for issues of program, physical and social context, and construction technology. Rather, the products of these interactions have widened the designer's total range of concerns and provided access to architectural forms not available separately through either manual or digital processes.

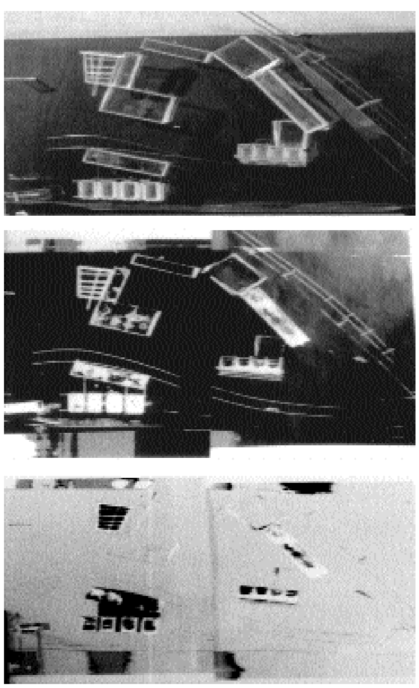

Figure 5:
(a) Plexiglas and Mylar model;
(b) scanned image of model;
(c) edited version of the scanned image.

Figure 6. Freehand charcoal sketch.

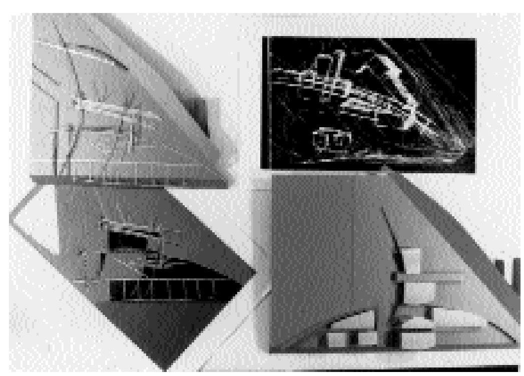

Figure 7:
(a) site model of circulation paths;
(b) scanned image of model after editing;
(c) further editing and inversion;
(d) site model.

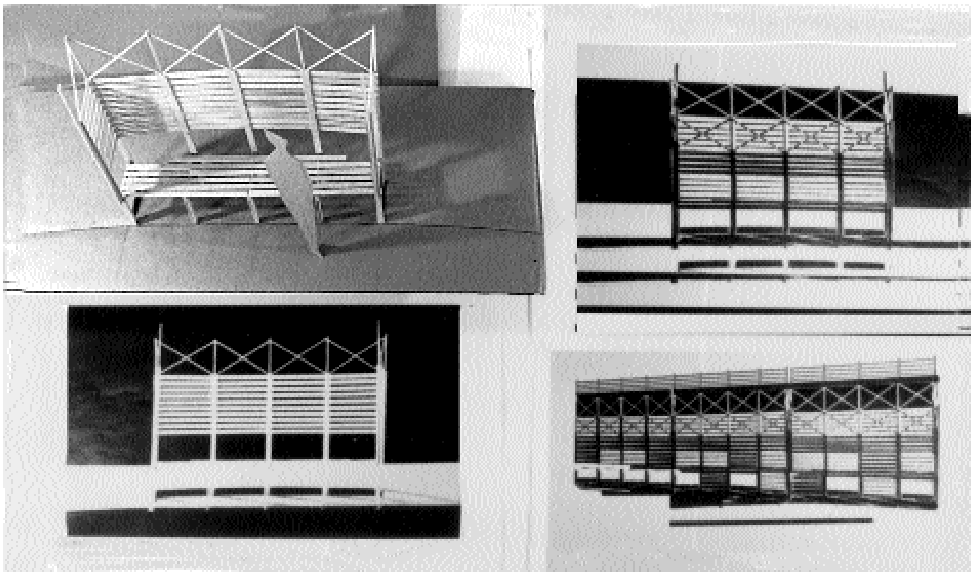

Figure 8:
(a) model of wood lattice and bracing;
(b) scanned image of model;
(c, d) edited versions of the scanned image.

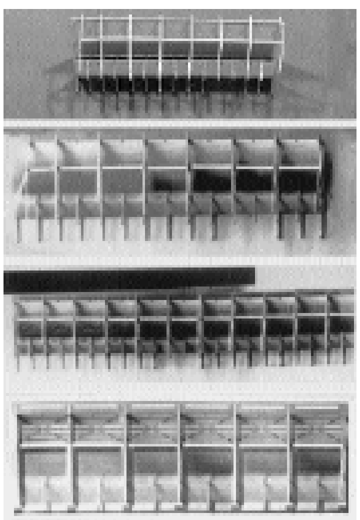

Figure 9:
(a) balsa model of multiple bays;
(b) scanned image of model;
(c, d) edited versions of the scanned image.

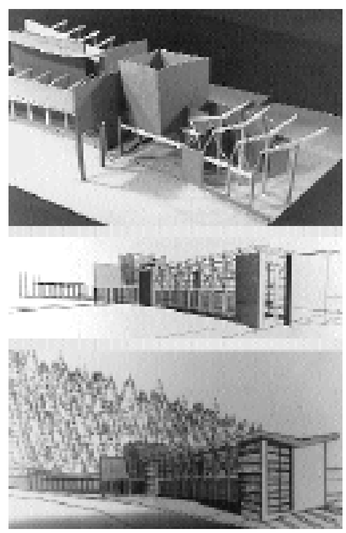

Figure 10:
(a) physical study model of entrance area;
(b) 3D computer model;
(c) 3D model rendered for final presentation.

References

Anderson, Lee, "Virtual Graffiti: Three Dimensional Paint Tools for Conceptual Modeling in UpFront." *Proceedings of ACADIA '92,* edited by Kensek, K. and Noble, D. (1992):127-134.

Do, Ellen Yi-Luen and Gross, Mark D., " Drawing Analogies: Finding Visual References by Sketching." [In this volume.]

Herbert, Daniel M., *Architectural Study Drawings* (Van Nostrand Reinhold, 1993).

Herbert, Daniel M., "A Critical Analysis of Design Processes and Media: Applications for Computer-Aided Design," *Proceedings of ACADIA '92,* edited by Harfmann, A. C. and Fraser, M., (1994.): 133-146.

Brown, G. Z. and Novitsky, Bobby-Jo, "A Macintosh Design Studio," *Proceedings of ACADIA '88,* edited by Bancroft, P. J., (1988).

Danahy, John, "Toronto's Approach to Computing and Teaching" *Proceedings of ACADIA '89,* edited by Yessios, C., (1989): 257-262.

Fargas, Joseph., "Design Mediums and Other Phenomena of First Generations CAD Practice," *Proceedings of ACADIA '93,* edited by Morgan, F. and Pohlman, R., (1993): 99-110.

Matthews, Kevin D. 1994 [Unpublished]

McLeod, Douglas, "Wiring the Academy," *Architecture,* (February, 1995): 137.

Novitsky, Bobby-Jo, "Freedom of Form," *Architecture*, (August, 1994):107-111.

Week, David, "The Database Revisited: Beyond the Container Metaphor." [In this volume.]