"REPRESENTATION IN THE COMPUTER AIDED DESIGN STUDIO"

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ABSTRACT

Application of commercial computer aided design systems to schematic design in a studio setting in a professionally oriented university provides the opportunity for observation of extensive use of CAD by designers with little or no orientation toward computing. Within a framework of studios intended to contrast media and highlight the issue of design representation, the most encouraging applications of computing have involved dynamic visual design representation. This paper presents a case study of three studios at the University of Texas at Austin together with commentary on the place of computing in this essentially artistic environment. It presents, in slide form, a body of aesthetically oriented CAD work which signals the spread of computer aided design out of the hands of researchers and into mainstream architectural design, where development of the visual and dynamic aspects of the medium may prove to be primary routes to improvement of its power and acceptance. Much like a first design project, this paper then presents a lot of observations without yet much rigorous development of any one. It asks implicitly whether application of software constitutes research.

FACILITY

Students and Systems
This work has been done by upper division undergraduate and graduate students in an elective studio. Many but not all of the students had completed a thirty hour software instructional workshop prior to entering the studio. Almost none had any programming experience, nor did many wish to gain any. There were twelve students in each studio.

This work was done in a specialized studio with one microCAD workstation for each student. In a fairly typical configuration, these stations were based on the AutoCAD and AutoShade software running on the PC AT with PGA graphics, expanded memory, and in two cases hardware zoom cards (Nth Engine). The base machines were granted in 1986 by IBM under Project Quest, which is the University of Texas branch of the IBM ACIS grants for innovative teaching. Software and peripherals came from local funding and industry discounts. The distinguishing condition here is that having is a computer for every student helps the possibility for a real studio.

This microCAD studio has two companion facilities providing an interesting context for the CAD studio: The first of these, the Visual Communication Lab, is quite unique in that it allows exposure to computer graphics to be a requirement for all incoming freshmen. Based on the paint and video capture technology made possible by Truevision, and introduced concurrently with a variety of manual methods, this facility introduces the concept of moving between media in
graphics. On the high end this lab offers the Lumen software on the TARGA board; on the low end, for the bulk of the work, it has the Imagit and PC-Eye packages running on the Number Nine Revolution board. These run on a dozen PC/AT workstations. The second companion lab, intended for three dimensional modeling applications, will grow into the school's main computing resource. Hardware here presently includes six Sun 3/110 diskless nodes running off a 3/280 server. Software applications included surface modeling (Arris), solid modeling (in-house program in development), environmental and structural analysis, energy simulations, and more AutoCAD. For full utilization, this lab really awaits stabilization of the homegrown solid modeler.

The studio attitude
From the point of view of the students, what we needed to add to the microCAD facility to begin to have a real studio was food and radios, all-nighters, and artsy clutter. More seriously, what we introduced was the studio tradition, which of course still dominates architectural education today long after introduction at the Beaux Arts last century. With this tradition we necessarily took on a certain mood, and in particular a situation where that the energy of the group would be the best indicator of the level of learning. To place CAD in this setting, we had taken the attitude that the more computing was integrated into the design process, the less it was kept to a technical elite or limited to use in design documentation, the better chance we had of discovery of expressive possibilities of a powerful new medium. In that sense we also shared the investigatory and aesthetic orientation of the studio tradition.

The luxury of this attitude is new. Whereas before, the cost and crudity of computing restricted its use to the domain of technical specialists with lengthy training and no real other way of working, recently the availability of inexpensive, powerful, and relatively easy computer graphics has made computing advantageous to many non-specialists wishing to create, organize and transmit graphic information. The calculations compiled by the word "computer" are becoming so transparent to the typical user that we need a better word for the device that performs them.

BACKGROUND

Representation
Without going into the particulars of signification, let it be said for present purposes that representation is interpreted to be a predominantly descriptive product, with some value unto itself, and is also a process, influenced by the characteristics of some tools. Thus “description” and “medium” may often be substitutable for representation. As a product, representation has, particularly in architecture, been noticed to bias that which it represents. The revolution in visual information processing made possible by the no longer so aptly named "computers" encourages reconsideration of CAD as a representation of design. Attention to some basics of this issue has thus become a central thread to the work in the CAD studios at the University of Texas.

Making Creative Marks
Creation of graphics is the basic process of representation in architecture. Thus a study of computing which promotes a technical understanding of how the computer makes marks is essential to beginning sensitive application of computer graphics. [Mitchell]. Also important is a study of how the computer changes marks. Illiteracy, or past experience with cumbersome systems, has produced a bias against the computer as a creative medium.

The belief exists among designers that it is at the moment of representation, when many ideas in mind produce a few on paper (or silicon) that creativity occurs and the implicit direction for development of a design first becomes evident. That the goal of many a designer is to reach the creative moment, even if by disorientation, accounts for much of the studio behavior. Cultivation
of such a moment is largely a matter of attitude, which in turn is much a matter of the feel of the tools, or what becomes, in a word, expression. The creative moment is an expressive moment. It can also be a pretentious one.

If design is a record of a conscious state, and representation is the record of design, then in the best case each is a vehicle. "The true miracle of the language of art is not that it enables the artist to create an illusion of reality. It is that under the hands of a great master the image becomes translucent". [Gombrich]. If the representation used in schematic design exists more as notes by the designer to examine images or to encode characterizations of possible solutions than to communicate ideas to others, then it is the designer's own feedback, or "visible speculation". [Graves].

Schematic drawing may be as much about identification of a problem as about solution. In unbounded or overconstrained design problems, the approach to the design decides much about which issues will be addressed. [Herbert]. What is more, exploration of design may identify issues which had not initially been evident. Drawing is about getting an angle on a problem.

Computer graphics, with its analytic precision, and with its absence of a substantial tradition to match other media, is in this world mostly eschewed as an at least constraining or at most totally inappropriate medium for creative work. No matter if you could be artistic with it; it doesn't express artistry. To many the message of this medium has been a combination of technocracy and loss of subtlety. This paper suggests that attitude could now be changing.

Intermediate Objects
Supposedly creative marks having been made, representation assumes a life of its own, and people become fascinated, whether in computer graphics or prismacolor drawings, with the intermediate objects often as much as with the designs those are meant to represent.

"The forms of art, ancient and modern, are not duplications of what the artist has in mind any more than they are duplications of what he sees in the outer world." [Gombrich].

How much those objects, or the media in which they are executed, affect the design is of course a matter of continuous debate. That student efforts at representation concentrate on formal issues and thus bias design toward artistic objects is less so. This paper presents a lot of slides as intermediate objects.

Resemblance
This paper suggests, (but does not have the scope to develop), that the distinction between resemblance, which is often the concern of visual designers working with images, and derivation, which is more the interest of technical designers working with constructs and performance specifications, is one critical issue in design representation with CAD. This comparison is perhaps that of art and science, but it is also not so different from Foucault's distinction between classical and modern thinking. Whereas visual artists, who work with images, and are always wishing when creating something unique to still make it reminiscent of something else, so as to have significance in our world of associations, modern engineers are more prone to work with quantitative constructs based on performance, so as to make their objects structured or behaved according to mathematical or other formal laws, regardless of recognizable appearance.

Another paper, not related directly to CAD, could develop the point that one thing to be learned from the problems of (systematic or quantitative) modernism is that the previous achievements (taxonomic or qualitative) classicism should not have been discarded. The need for psychologically familiar form suggests retention of previous layers of evolution, as well. Meanwhile, designers remain obsessed with the invention of new forms.
Figure 1  Emergent Motif

Figure 2  Pavilion from Motif
This paper tries to point out that the improved means of image manipulation in CAD allow for restoration of support of visual processes on top of powerful quantitative constructs which can become transparent. The missing layer of associations, (usually with precedent), can be restored.

"There must be, in things represented, the insistent murmur of resemblance: there must be, in the representation, the perpetual possibility of imaginative recall."

[Foucault]

What is at work here is visual cognition, namely comparison and recognition, an area in which the minimal progress by systems based on sequential processing has called attention to the enormous and perhaps more holographic capacities of our own minds. For the moment, visual cognition is best served by CAD in the manner of producing a lot of images and leaving the interpretation, recognition, and accidental discovery to us.

**Technical Developments**

Technology is perhaps advancing most rapidly in just that -- the production of images. The proliferation of bitmapped drawing and imaging software, particularly on the Macintosh platform, is most promising. Real time playback of stored images is coming along, too. More to the point here, the capacity of everyday CAD, paced by standard AutoCAD, to manipulate images while creating them has increased substantially. Within CAD, the use of display list processing, or image space transformations, together with the presence of means for juxtaposing images, has changed the feel of the medium. Such processing allows for continuous feedback of results of transformations, based on pointer position, until a particular point is input and the actual drawing database is updated. This might apply to viewing transformations, such as zooming, or to geometric transformations, such as scaling. In any case the difference is that now the designer can initiate a transformation without knowing what its parameters, and can then select those parameters based on visual recognition of a desired condition from within a continuous range of results. With a full command trail, one can undo a complex series of operations. With split screens, it will be possible to compare views or (not yet in autocad) versions. Transformations performed at the hardware level, (as first made popular by Silicon Graphics), which improve the feel of a system by reducing response time, have reached everyday viability too. What all this means to the user is that it is becoming easier, whereas formerly it was often harder, to alter a design representation on the computer than by hand.

**STUDIO CONTENT**

Each of three microCAD studios that have been conducted in our School of Architecture have taken a distinct approach to representation:

**Two Dimensional Studio**

The first studio, conducted during the spring of 1987, applied classical compositional principles in two dimensions. Using the well developed two dimensional capabilities of AutoCAD and ignoring its then insufficient three dimensional power, the studio set out to reexamine graphic design fundamentals in the context of the new medium. The work was in a series of separate exercises focusing in turn upon graphic type, variations on a theme, rhythm, symmetries, layers, proportion, and hierarchy. Each of these weekly projects resulted in a graphic composition, usually for a facade. The compositions were in terms of well defined architectural types, such as a series of row houses, a paving pattern for a church, or a plan for an office tower.

The representation in this studio was strict, constructive linework. The studio intended to convey the value of working within the discipline and constraint of CAD in order to achieve a new expression. But while working under the rules of precise drafting, the students produced compositions whose value was as much in appearance as method, and more in resemblance than derivation. In doing this they could learn that the constraint of CAD need not be a disadvantage.
Figure 5  Example from 2D Studio - Symmetry Study

Figure 6  Example from Mixed Media Studio - Rendered Section
They could also dwell upon formal content of the most basic sort, which in the face of a wider set of concerns, such as site and program, they might otherwise ignore.

Two longer projects allowed the students to apply their understanding of the medium to the rendition of first a famous work of architecture and then a design of their own. The students produced more work here because the tools they had were better suited to documentation than design. The comparison of the highly detailed CAD drawings and the manual works from which they had been interpreted called attention to the qualities of representations and their independence from the objects described. On the other hand, the difficulty of designing original facades without reference materials or the ability to sketch pointed out the need for appearance and emergent form in the design process.

**Mixed Media Studio**

The second studio, conducted in the fall of 1987, deliberately ignored issues of method in computer aided design and concentrated instead upon building design. The goal here was to offer CAD alongside conventional media and to allow the students choice in when and how to apply them. We added a conventional studio space with drafting tables to our facilities. We gave short problems to challenge the students to become familiar with available options, and suggestions for presentation requirements to encouraged mixing of media, but did not require any computer use at all in the semester design project. Student responses ranged from exclusive use of CAD by a few, through documentation use by most, to futile last minute efforts, or no use at all by some. Representation was conventional, i.e. dominated by 2D drawing (plan, section, elevation), whether by hand or computer, but also included some 2 1/2 D wireframes. Late introduction of rendering software (Autoshade) encouraged some good visualization work from the wireframes. Experimentation in mixed media included combination of plots with airbrush, colored pencil, and crude combination of video capture and montage with white models. However, for the most part, without any guidance in alternative representations, most students using CAD were only mimicking manual methods, i.e. drafting.

**Three Dimensional Studio**

The third studio, which took place this spring, used three dimensional CAD as the sole medium. While logistics prevented us from using a solid modeler in these efforts, we did have an adequate surface modeler in AutoCAD and AutoCAD enhanced with a set of three dimensional primitives, (box, cylinder, tilt-up, etc.), by means of prepackaged and home programmed routines in AutoLisp. These we added to the standard menus so that except for the factor of slowed performance, they appeared to the students as part of the system. As a result, most students were able to overcome the limitations of 2 1/2 D to create sophisticated models for lighting and shading with Autoshade. To reduce the complexity of learning these tools, we worked our way with weekly exercises from 2D to extrusion to composition of 3D primitives to shading. In doing this, we worked at the same time through a series of architectural elements: proportioning system, base, walls & columns, roof. [Fig. 12], and finally assembly of elements into a pavilion. [Figs. 13-14]. Having developed confidence with these projects, we then spent the last few weeks doing a design project with a simple site and program. In this case, in contrast to the second studio, we required that all work beyond initial concept development sketching be done on the computer. Also unlike that studio, here enough students had sufficient expertise to avoid simply drafting electronically. 3D line and surface, a little more static that necessary here because of the capacity of the hardware, became the dominant representation.
Observations

Threshold
The first observation from all this work is that conscious use of computing for design and not just documentation has a high threshold which most students without specific guidance in the new medium and freedom from a full range of architectural constraints do not reach. The work that all the students do is largely intuitive. The argument exists quite commonly among them that the rationality, spurious precision, and just plain ergonomic inconvenience of sitting in front of the computer can only interfere with their conscious design state. For the distraction to be worthwhile, something unique must be offered; the fact that in our studios the students who bring more to the table as mature designers are the ones who see some light suggests that fortunately something is.

Dynamic Image Manipulation
The primary comment here has been that worthwhile use of CAD usually involves dynamic manipulation of images, such as real time geometric transformation, to investigate numerous variations of a design, whereas ineffective use has been an imitation of manual drafting, in which some aspects of the design have been detailed to excess in comparison to others which have been neglected. The power of computer representation for schematic design lies in production of a continuum of variations from which to recognize a desired solution, the weakness is in the distractions produced by spurious precision.

By working visually, using continuous geometric transformations to virtual images (e.g. “dragging”), CAD allows arrival at forms independent of derivation. By working with graphic constructs and constraints, it does not require the designer to remember so many numerical values to describe a design. In such cases, cartesian precision becomes transparent. Addition of dynamic editing capabilities, even if limited to a few linear transformations, to today’s systems was one of the best steps toward their usability in design.

Spurious Precision
The dimensional precision offered and usually required by computing has been unnecessary or even misleading. Because in the past very precise drawings have only been produced after much thought, out of habit we take the precise CAD drawings, which may only be about tentative relationships, too literally. [Brown]. Because spurious precision can be distracting, students tend also to perform detailed resolution of only insignificant aspects of their designs.

Schematic CAD
Because the work that architecture students do is mostly schematic design and hardly at all the programmatic research or project development and documentation for which computing has become useful in the practice of architecture, application of CAD in the studio tends existing software in new directions. There are many incentives to improve schematic CAD. For one, practicing designers will wish to avoid difficult media transitions as a design develops into documentary stages where the benefits of the medium may soon be a competitive necessity. Also, there will be a technology and novelty driven tendency to apply the computer wherever possible, whether appropriately or not. More importantly, there may be an opportunity for designers to make better decisions if they have better information support systems, or a hardship for them to resolve increasingly complex problems without the same. Next, there is also a real possibility of using a dynamic design medium to understand better and to explore designs and to convince the public more fully of their worth. Finally, and closer to the subject at hand, there is need for people to learn design and computing together.

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Fundamentals
If there is an advantage for all it is that computer aided design is sufficiently different from habitual methods that it allows and even requires reconsideration of design fundamentals that we might otherwise tend to forget. The relative success of our projects in symmetry and proportion or in base, walls, and roof relative to more full scale or less structured projects illustrates this condition. Furthermore, the organization required for CAD utilization encourages some hierarchy and premeditation in design work that is otherwise mostly improvisatory. Consideration of some basics could direct further work in design computing.

DIRECTIONS
A few possibilities for work in dynamic design representation using the computer have been imagined during the studios described. They are presented here, often without any sense of viable realization:

Rapid comparison of multiple models, or versions, by moving up and down a command trail, or even branching that trail, follows after rapid alteration of a single model. Recombination of existing subassemblies in a hierarchy, (as in the Dimensions software package), would be a related principle.

Representation used must allow for work on the basic organizational devices that give a design an identifying structure, for schematic design determines relations between parts, or topology, whereas the omitted later phases of the design process would determine the particular measure of parts, or geometry. Variations must be in the logical structure and not simply the measure of designs. [Liggett & Mitchell].

Representation can work dynamically with resemblance by providing visual information support in a workable form. [Purcell].

Dynamic integration with other media would allow for movement between levels of precision. While exchange of bitmaps extracted from various levels of representation is a reality now, a true "gearshift" in the amount of information the designer confronts on a model remains a fiction.

SUMMARY
Architectural education at The University of Texas has provided an environment where concentration on application rather than development of systems has produced work that suggests directions for improvement of the computer aided design medium so as to better serve the needs of mainstream schematic architectural design. Work in the studios here has indicated that the accuracy which has been the primary professional advantage of CAD may not be the most important aspect in education. Instead, we are at the point in ordinary CAD capabilities where we may begin to consider dynamic editing and comparison of images and models and linkages to other computer graphic and visual information media to be at least as important as precise analytical description in computer aided representation of design. More important still, we may begin to use those facilities to produce work which begins to really explore the aesthetic nature of a new medium.
REFERENCES


ILLUSTRATIONS

Figure 1 Emergent Motif
Figure 2 Pavilion from Motif
Figure 3 Developed Pavilion - Wireframe
Figure 4 Developed Pavilion - Shaded Surfaces
Figure 5 Example from 2D Studio - Symmetry Study
Figure 6 Example from Mixed Media Studio - Rendered Section
Figure 7 Example from 3D Studio - Pavilion
Figure 8 Example of Fundamentals - Proportion

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