ABSTRACTION AND REPRESENTATION:
COMPUTER GRAPHICS AND ARCHITECTURAL DESIGN

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ABSTRACT
While there is evidence to support that many important aspects of architectural design are not graphically based, but analytical in nature, there remains a long history of design exploration dependent on representation. Furthermore, methods of imagery are frequently so intertwined with the meaning or character of the architecture that it is not possible to effectively replicate the architectural intent with a different medium or graphic style. From Erich Mendelsohn to H.H. Richardson to Richard Meier, the type of graphic representation expresses and gives essential clues to the issues and organizational principles that the architects felt were integral to the very nature of the design.

Computer based graphics remain a comparatively new medium. Often, designers tend to utilize this medium for conventional purposes. While each image (plan, perspective, etc.) is modified by the electronic medium, it is the simultaneity of the computer model, coupled with completely new dynamic qualities and holistic capabilities, which results in visual representations that are at least as influential on the product as traditional media historically have been.

The following paper analyzes various types of computer graphics to demonstrate the relationship between these types of computer graphics and architectural design. Specifically, the impact on design of the formal characteristics, site relationships and constructive qualities of buildings is illustrated. A taxonomy of graphic styles and associated architectural projects is developed. The paper shows new design explorations and techniques, and illustrates the assortment of images which extend the scope of a designer's responsibility thereby transforming the design process and architectural product. Beyond parametric studies of geometric properties, a variety of design techniques is presented which explore both the dynamic qualities of the electronic medium, and the relationship of the new medium to the process and product of design.

Based on experience during a three-year period with over 150 students, in which the primary purpose of the use of computer graphics was the development of architectural design, we have found that the new methods of representation extend our understanding, evaluation and development of physical environments. We experience and are able to design an unbuilt architectural world in a perceptually different and dynamic manner.
BACKGROUND/INTRODUCTION:

The methods of graphic exploration that are chosen during the architectural design process have a clear impact on the product of the design. The types of images created and evaluated, as well as the items selected for representation, influence and/or determine the character of the building. It is hard to imagine, for example, Michelangelo's design of the Capitoline Hill in Rome, or his creation of a visual focal point in the Belvedere Exedra without the use of (one point) perspective. Mendelsohn's free flowing expressionist sketches seem to be a more pure example of the architect's intent than the buildings themselves. His Einstein Tower in Germany, whose drawings attempt to express the dynamics of movement, is a primary example of the relationship between image and design intent.

The graphic representation of the De Stijl movement epitomized in the Schroeder House by Reitveld, demonstrate a near interchangeability and equality between representation and product. The abstract geometric forms of I. M. Pei are stunning images in axonometric ink drawings. The 'character' of Pei's buildings is, very likely, a result of this favorite representational technique of modernist architects, and like the drawing type emphasize conception over perception.

There are, clearly many different graphic types and styles (within the categories of 'traditional' and computer generated images) available to an architectural designer. Each type of image gives insight about different aspects and opportunities in design. Areas that are studied reflect the 'biases' of the designer or the limits of the particular representation or graphic style. For example, a traditional elevation drawing deals with two-dimensional relationships at the surface of the facade and tends to emphasize compositional relationships of color, pattern and/or geometry. Other types of representations enable the designer to study the relationship between intersecting planes and corners, connectivity between interior and exterior or issues of scale.

This paper illustrates some new types of representations or graphic processes that are available through the use of microcomputer graphics and illustrates their impact on architectural design (or, how the design results from the graphic representations). All work shown was created in architectural design studios at the New Jersey Institute of Technology. Of greatest significance are the graphic techniques and groups of representations that offer potentially new insights to design and influence the way we create and evaluate architecture.
SLICING:
The ability to look at selected sections or pieces of a project. Slicing extends the traditional section drawing by varying the thickness of the slice, and permitting slicing through the building at numerous angles and locations.

The designer can explore the relationship between interior and exterior, solid and void, parts and whole, etc. A solid mass can be dissolved into an increasingly volumetric space with voids. This is not accomplished with the creation of each slice as an independent two-dimensional entity, but dynamically through the creation of 'near' two-dimensional elements which simultaneously remain in a three-dimensional context and with relationship to the entire building.

The adjacent illustration of student work shows a complex three-dimensional frame which has been sliced into elements of limited thickness. A series of slices shows the progression from a solid facade and exterior zone, to a hollow public interior space. Each component or slice can be evaluated independently. The student is able to test his organizational concept against perceptual criteria.

More than a decade ago Gerhard Kallmann and Michael McKinnell wrote "Movement Systems as Generator of Built Form" which served as an introduction to and explanation of their work as published in Architectural Record in November 1975. At the time, their work was best understood through the use of "slices" - in their case, sections and one-point section perspectives. Buildings like the linearly extruded Exeter Academy Gymnasium show the link to these representational techniques. As exciting a structure as it is, the building's development may have been altered if the architects had the opportunity to investigate slices of different angles, locations, and thickness.
INVERTS:
The relationships between figure-ground, solid-void, building-path, etc. as seen with simple inverts of color.

Each set of objects system can in turn be studied as the focus, in the context of the entire composition or context. As the hue, intensity or value of color can be directly changed, the degree of emphasis of parts in the composition can be studied. Rather than the traditional black/white figure to ground study, many color layers of varying importance and/or interrelationships can be created. Objects in space or the space around objects can be amplified. Paths versus places can be defined.

RE-SCALING:
The changing of the scale of a line, component, group, object, or entire building. Re-scaling gives designers the opportunity to rapidly study alternatives of size and relationship.

It is the process of re-scaling that became an important component of many of the earlier design studies that were performed under the direction of Professor William Mitchell at UCLA and as explained in March and Stedman's book The Geometry of the Environment.

The impact of the height of a tower, in the example shown, can be studied in minute detail. The size of objects, portions of a whole or the whole building itself can be immediately changed. Buildings can change emphasis from horizontal to vertical, and back again, to study both the self-referential impacts as well as the contextual results.

Questions of landmark, symbol, or focal point are evaluated in space and from multiple vantage points and in series. The appropriateness of "size" as it relates to human scale, the existing built context, and demarcation of building components can be evaluated comparatively through the development of parametric studies.

Whether scale is varied in the complete three-dimensional model or in a two-dimensional "flat" image, appropriateness of size is always a critical question during the architectural design process.
SERIAL VISION:
The ability to create a series of interrelated complex perspectives. This technique enables the designer to explore various approaches to and through a building, or sequences of movement (both in view and design parti).

The design emphasis is on the designer's relative position in space and the experiential changes that occur through movement. Variety of enclosure, axis, scale, etc. can therefore be simulated. A traditionally generated "perspective" is singular in viewpoint and illustrates special vantage points. Single perspectives tend to focus upon unique points of view, views on axis, or locations of great importance. A serial vision group can illustrate both special vantage points and sequences of views which closely approximate daily experiences. A series of views or a simplified animation can be produced manually and therefore, this technique may at first glance appear to be a duplication of traditional methods. However, the computer can assist in the production of these representations at a speed and degree of interactive flexibility that makes them a useful part of the design process. To accomplish the same task in a traditional manner requires an enormous amount of time and the resultant representational products indicate that doing it "by hand" lacks in accuracy and dynamic impact.

Finally, because of the ability to quickly change viewpoints, station points, angles of rotation, etc., the designer is not inhibited either by time constraints or complexity of form and concept.

The project illustrated has as its organizational idea the progression of a views from what appears to be a simple solid volume on the site to a transformed solid with a void at the diagonal entry and a hollow interior volume. The accuracy of the representation facilitates the simultaneous development of the structural frame, site orientation, and circulation system.

"To walk from one end of the plan to another, at a uniform pace, will provide a sequence of revelations which are suggested in the serial drawings. Note that the slightest deviation in alignment and quite small variations in projections or setbacks on plan have a disproportionately powerful effect in the third dimension."

Gordon Cullen, TOWNSCAPE
3D ABSTRACTION:
The ability to create conceptual or abstract models of relationships in three dimensional space.

3D Abstraction transforms the two-dimensional geometric constructs into space. Axes, grids, proportions, symmetries, patterns and other conceptual notions are studied in context of human scale, sequence, and as space defining relationships. Whether in the analysis of architectural precedents or in the creation of new architectural forms, organizational patterns which were limited to surface or linear types can define rooms, buildings, neighborhoods and cities. As a designer works interactively between two-dimensional patterns and three-dimensional representational models, the abstractions of geometry become ordering devices for "realistic" architectural space and constructions.

SURFACE/STRUCTURE:
The simultaneous study of interaction of volume, surface and structure in three-dimensional and two-dimensional representations.

A designer's focus on two-dimensional surfaces may, at times, lead him/her to (over) emphasize surface decoration as an end in itself. Buildings run the risk of becoming arbitrarily stylized to the point of trivialization without clear thought to any meaning of the building beyond mere decoration. If the volume is simultaneously being viewed from varying angles during the modification process, there is a dialogue between surface details and the building as it will be experienced. Buildings can vary from elegantly simple forms with little textural detail, to complex volumes including elaborate surface patterning within is single representational system. Repeatedly varying from two to three dimensions, within a single architectural model, facilitates the designer's ability to make choices between surface (2D) or form (3D) enhancement.

In the representation shown, a cube can have a truncated corner with little result in the two-dimensional drawing beyond the addition of a few vertical lines in elevation. Threeimensionally, however the designer becomes aware of the sculptural and formal impacts. The designer can proceed with two-dimensional studies aware of the these implications. Few media (scale models, computer generated images, etc) permit the simultaneous and dynamic study of detail and form. A difference between the computer image and the scale model lies in the ability to change it rapidly, subject it to some of the other modifications mentioned in this paper, and to walk inside and around the "model".
WINDOWING:
The location of openings, windows, and frames and
creation of vantage points and views from buildings in
design.

People often experience architecture through a series
of views and remembered images. As we travel
throughout and around buildings we are aware of
unique vistas or framed images. Unless trained to
"see" in the abstract forms of plan or section, an
individual's understanding of architecture may be
based solely upon these experiences. Additional
experiences are created as the individual walks through
a building and looks out onto the landscape or towards
other parts of the building.

Although architects often speak of framing views, they
are only occasionally able to "window" a building
accurately. The most precise method would allow the
designer to locate openings at the site. Unfortunately,
this is only possible during the construction process
when most design decisions have been fixed. An
alternative method was recently described in a trade
magazine for builders and developers:

"Views are often a condo's biggest draw but
even the best architects sometimes have trouble
visualizing site lines from the 14th floor. So First Realty
Associates, Inc. in Stamford, Conn., is taking no
chances. For $5,000, it hired a crane and photographer
to snap views from various levels in its planned 300-unit
downtown condominium. Stamford architect Michael
Blanc is using the information to help place the site,
angle, and dimensions of windows, balconies, and
interior spaces..."  (BUILDER, June 1988, Vol
11, No. 6, p. 88)

In the example described above, once the views are
photographed, the dynamic interaction between
architect and product during the design process is
curtailed. However, the dynamic qualities of
animation and creating landscapes and buildings in a
holistic manner with the computer in the beginning
phases of design allows windowing to become an
integral part of the designer's understanding of
the building. While not a substitute for seeing actual views
at the site, the computer-enhanced windowing allows
for a more precise study of opening locations.

The student project illustrated, a hotel in Hawaii, is
designed to give the guest a series of different
impressions from the land, within the building, and
from the water.
PARTS < WHOLE:
The creation of a kit of parts and/or modules within
the context of the building in its environment.

Exploding and combining elements into wholes has
implications both formally as well as in the
construction process. Frequently, the combination of
the parts is the simple process of stacking or sticking
elements together, resulting in a fragmented building
which is merely the sum of the parts. The computer
enables the designer to create combinations which are
more complex and interesting, and in a context where
the entire building can be viewed holistically and
realistically, rather than a simple assemblage of pieces.
The process combines the conceptual linking of
modular elements and the sculptural qualities of
building as a whole, similar to a physical scale model
constructed from solid elements (wood, styrofoam,
etc.). The ability to re-position parts in space, change
their size and color, interactively add and subtract
elements as well as slice, serial view and window the
assemblage, makes the computer based model
different from the traditional process of constructing
physical models.

"Architecture begins with the simple assembly of
physical things, which by the way they are put together
begin to embody the dimensions of magic. Good
architecture is a single thing, as well as a collection of
many. To make it requires conceptual leaps from
individual ideas to a vision of the whole."
Charles Moore

In the example shown, each relatively simple element
in the synagogue design is derived from research about
Judaism and its historic roots. There is an immediate
understanding of the interaction of the parts and how
the modification of any part will impact the form and
its place in context.
COLORIZATION:
The ability to create, evaluate and transform alternative color schemes.

Studies can include the visual interaction of materials, surface treatments, seasonal changes, relationships to the landscape and the difference between day and night. Combined with pixelization, texture and reflective properties can be studied. The impact of warm vs. cool schemes both on the interior and exterior can be evaluated. As the designer varies hue, intensity and value of each color while viewing the architectural image, color and the resulting visual emphasis is created interactively on the building and physical context.

PIXELIZATION:
Transformations of the precise definition of surfaces and edges to a representation that includes greater detail, is more personal to the designer, involves selective editing by the creator and electronically returns the model to a sketch format similar to the freedom and directness of freehand rendering.

Limiting the computer media to plain undifferentiated surfaces inevitably leads the design to freehand sketch overlays, both to add qualities which enhance realism and scale, and to permit the designer an interactive media for design. Monochromatic surfaces are not eliminated but "half-tones," quarter-tones," etc. are made available. "Irregular" combinations of colors can result in a computer image reminiscent of expressionist 'pointillist' paintings. The ethereal - and personal - qualities presented in the images can find their way into the product with the selection of finish materials and surface texture as well as choices in landscape design. Pixelization permits the designer a high degree of graphic choice, style and attitude. It also involves a high level of dynamic interaction between hand and computer. Although limited to a pixel defined image, the designer can create images based upon choices at 300,000 points from hundreds of thousands of colors. The choice and variety of images ultimately results in representations which express the "style" and aesthetic preferences of the designer.
TRANSFORMATIONS:
The transformation of wire frame images to surface models. The process of creating the transformation allows the designer to consider options for the expression of the collision of line, surface and plane.

The “wire frame” representation relates to the study of parts in space and planes across space. Because the representation is transparent, the design issue becomes the study of planes and the extension of lines. Intermediate levels of transforming lines to planar surfaces are a valuable technique, as the designer selects and interacts with the representation of space and enclosure deciding which extensions of line or plane to emphasize.

SEPARATIONS:
A perceptual study of the separation of interior and exterior space by “filling in” areas or “stopping down” the opening in order to explore the connections between spaces and the definition of spaces.

The designer is able to dynamically set and remove visual boundaries and create spatial adjacencies. Surfaces can be defined by line, (opaque) plane, or combination. Additionally a study of relative proportions of opaque and transparent treatments can be evaluated.

Decisions based on visual criteria may also have construction implications when fenestration changes. Bearing walls can dissolve into structural frames. The limits of space are emphasized not only in a formal sense but also in the programmatic questions of privacy (visual and acoustic), environmental enclosure, etc. This type of study becomes particularly useful when a designer seeks to explore the visual implications in those areas where energy conservation subcodes regulate the maximum percentage of different types of glass in a building.

The project illustrated shows the dynamic infill of surface varying exterior boundaries and the separation of interior and exterior space. In this example, the construction type is fixed and only the percentage of glass is varied. One is able to stand either inside or outside of the building and evaluate window placement, privacy, aesthetics, and contextual relationships.
CONCLUSION:

Microcomputer graphics enables the designer to manipulate a variety of different architectural representations which inform the design process in new and significant ways.

While there may be some types of design that do not rely on graphics, it is clear that there can be no architectural design investigation without graphics. Many decisions are determined by the graphic process, from building organization, form, site relationship, visual character to aspects of construction detail and livability. Architectural design is highly dependant upon the interaction between what is thought or conceptualized and what is discovered through observing visual sketches, models, drawings, etc. Because design, especially architectural design, begins in a multi-faceted world with few knowns and many possibilities, the use of graphic media, which informs the designer about both the abstract and realistic characteristics of the building throughout the entire design process, and enhances the dynamics between thought and product, can have a significant influence upon the built environment.

Furthermore, the advent of computer graphics has forever expanded the responsibility of the designer to understand the qualitative aspects of our built environment while increasing the possibilities for architectural design.

There are now ways to study issues that heretofore had only been imagined, vaguely discussed or, more often, ignored. The way proposed buildings are understood, manipulated, and experienced is fundamentally altered by new graphic techniques. Just as the introduction of one-point perspective changed the focus of architecture in the past, so too may the ability to "slice", "window", "re-scale", etc. may influence design in the future. Adding new processes and graphic types to the existing list of design activities and products, expands the scope of form giving techniques that can be used in the creation of architecture, while changing the way we experience and produce buildings during the critical stages of architectural design. Perhaps the most significant aspect cannot be shown in this paper. The dynamic ability, in real time, to modify, change, save, recall, and study designs, using these and other techniques, in an interactive manner brings new power to the designer and may result in a new and better informed architecture.

LIST OF WORKS CONSULTED:


