Capturing the third dimension

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So many of the things important to us begin on a designer's drawing board. Before a building is built, before an airplane wing is actually constructed, before a new fashion style is produced, some designer spent untold hours mixing many different drawings and calculations to reach an acceptable "blueprint".

What designers need from a computer system is the capability to dictate a change in a plan or design and then receive instant feedback about the graphic and numerical results of that change — some sort of real-time, interactive capability. At Columbia University, such a system has been developed to aid architects and it may have far-reaching effects on methods of design and development in other fields as well. For what it does is tailor a general computerized graphic display terminal (the Adage-50 with a 16k memory) to the task of designing real-world structures.

Two major system capabilities ease the architect's burdens: First, the computer very rapidly and precisely makes all the calculations which go into the development of major constructions. It stores the results and can report them to the architect on command. Second, the graphic display device can draw almost any configuration an architect could possibly wish. Not only will it draw or re-draw these hundreds of times faster than any draftsman, but it can do something a draftsman can't.

Getting the perspective

If the architect wants to take a look at how one of his buildings might appear in three dimensions, he tells the system its mathematical characteristics. He does this by rotating dials on a special console provided with the terminal. His movements of the dial are translated into instructions for the graphic display device. It can answer almost instantaneously with the desired 3-D view. Furthermore, he can use x, y and z coordinates to select any segment of the structure. The system uses wired-in "windowing" circuitry to automatically cut off lines that would lie outside the area of immediate viewing interest.

But the Columbia system carries this capability a step further, for it has been programmed to respond to a request with four different views of any structure: site plan; depth; width; and orthographic projection.

The orthographic projection can be made to rotate
A new man-machine system has the architect do the creating but lets the computer do the calculating and drawing — in three dimensions yet!

and effect strong structural realism. By varying both the speed and angle of rotation from his console, the architect can view his construction as it will appear in the real three-dimensional world — from virtually any angle.

In conversation with the computer

The architect can enter into conversation with this system. He can ask his computer questions about what will happen to a construction if a change in design is made. He can query the computer about the total area used at any point in the design, about the cost involved, about almost any variable pertaining to the building itself, the construction location or the design criteria.

The system will answer him almost instantly, for all through the design process it has been making relevant calculations and storing the results. It also knows how to calculate the effects of design alternatives the architect might need to consider. As an architectural accountant it is superb.

By this continuous monitoring of critical parameters of the architect’s work, the program can graphically present current information on almost any aspect of a construction during the entire course of the design process. The designer can know at all times how far he is from his structural goals; yet he has complete freedom as to the size, shape, position and orientation of his structures.

Almost any detail in his design can be altered programmatically and a three-dimensional perspective immediately made available. There is also an immediate playback of related numerical information as part of the dialogue between the machine and the architect. He asks, ‘What happens if I change this?’ and the computer can instantly return both graphic and numerical answers, answers it would take hundreds of times longer to develop by hand. When the architect wants to know what will happen to his overall design if he changes a single aspect of a building — or of a part of a building — he tells the computer what changes he wants to make. The computer can then send him back the spatial, computational and structural conditions which will be initiated by the change. More than this, it can actually show him what effect the change will have by redrawing the design.

This real-time informational feedback enables the architect to evaluate many alternative solutions to any design problem. He can, with the computer’s aid, avoid...
The Third Dimension...
(continued)

a major pitfall: Becoming committed to a solution too early in the exploration phase because of the investment in time required to approach an optimal solution using ‘hand’ calculations and drawings.

Getting to work

A construction site is made to appear on the CRT. In the case illustrated here, the site is part of the Columbia University campus.

The cluster of buildings which you see in the photograph is simulated on the face of the system’s CRT. The dotted rectangle reflects the placement of the proposed new building in the center of the photographed campus complex.

The two-dimensional CRT representation can be lent a volumetric (three-dimensional) quality simply by adding lines and shifting the axes. Now the architect has a more accurate view of the relationship between the spatial demands of his new building, the site environment and existing structures.

To proceed toward the actual design of the structure itself, the architect selects some basic ‘building blocks’ by depressing a function switch on the console. These ‘blocks’ can be varied in height, shape, width, or length by simple console operations. By manipulating console controls, the architect can gain the required ‘volumetric’ dimension.

Once a block is selected, the architect may then do any of several things:

- Change the dimensions of the unit in the north-south direction and alter depth.
- Change the dimensions of a unit in the east-west direction and alter width.
- Change the building’s height.
- Adjust the rotational orientation of the building to gain new perspectives.
- Construct walks, walls or windows.
- Add adjacent units.

So, by manipulating a few of the switches and dials available on the console, highly ‘realistic’ structural representations can be developed. Moreover, a single perspective on a structure can be made to fill the entire screen to give greater details. Then, if he wishes, the architect can generate four simultaneous views of an entire complex of buildings. And he can change or delete any image at will.

Getting the figures

The design drawings are stored digitally in the computer and any degree of accuracy can be maintained. The current program stores information to the nearest foot. However, it is easily possible to increase the accuracy to a fraction of an inch.

At any rate, the following items can be simultaneously tallied and displayed for the ‘block’ currently being worked on:

a) North-south dimension
b) East-west dimension
c) Height in number of floors
d) Height above or below level zero
e) Area of one floor
f) Gross area (floor area times number of floors).
In addition, the gross total area of all the units on the site is constantly displayed. On request a teletype printout will give all the following information for each of the units worked on in the current design:

<table>
<thead>
<tr>
<th>MODEL NO. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>GRAND TOTAL AREA</td>
</tr>
</tbody>
</table>

Computational information available in real-time

More to come

Because a building being graphically portrayed is also being defined numerically (in terms of its dimensions and structural interrelationships,) many additional computational options come to mind. Those slated for the immediate future include:
- Calculation of net-to-gross building areas and ratios,
- Summation of costs based on successive additions to area and volume,
- Running quantity and cost surveys of materials,
- Optimal space allocation algorithms.

But there will be advances on the display side as well. Currently the authors are programming the system to remove all lines from the CRT’s portrayals which would be hidden to a viewer looking at the real-world structure. Soon, for those architects working on major apartment and office complexes, a feature will automatically propagate a single floor plan through all the stories of a building.

The architect in the family is Genevieve, who earned a bachelor’s degree in architecture from Columbia after a stint at Cooper Union. Her major interest is in making the computer work for the architect, assisting in the planning and design of very large and complex construction projects. But she gets a little help from Lou Katz, whose doctorate is in theoretical physics and whose major interest is in molecular biology. For he’s currently the director of Columbia’s Graphics Facility for Interactive Displays.