Computers in architecture

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ABSTRACT

The union of computers and architecture has not come about in spite of glowing predictions over the last ten years. This paper describes several of the reasons why this may be so: the complexity of the profession, the inattention as to how the architects actually design and the lack of top management dedication. The current state of the architectural profession is explored and why the architect's entry into new areas should spark a demand for computer technology is discussed.

INTRODUCTION

Over ten years ago, articles extolling the wonders of computers and predicting, in glowing terms, their impact on architecture began to appear. What has happened to this prediction—why has it failed? To understand this turn of events, we must look both at computing, and at architecture itself. Perhaps there, we might find clues regarding the introduction of new techniques into old professions that might even have more universal implications. What is the state of architecture today and of computer utilization in architectural practice? The architectural profession, as we know it, is going through a major upheaval. The recent deterioration in the economy has had a strong negative impact. Statistics from the New York Chapter of the American Institute of Architects state that architectural commissions have declined 55 percent from the year 1972 to 1973 and dropped an additional 50 percent in 1974. Reflecting this, the employment level shows a drop of 75 percent from 1969.

Some architects are now beginning to ask the question . . . how did we get to be so non-essential? In a time of rapid technological change and increasing costs, long established practices must be reevaluated in order for the profession to continue its existence. Architects are still designing buildings by hand—row upon row of people bending over drafting tables draw the details of each building.

In situations where resources are limited, the architect must be able to explore alternatives to building, to financing and to forms of energy utilization. With costs escalating, he must solve problems that are more complex and solve them faster than he ever has before. The architect must recognize these new needs and adapt his skills to solving these new problems.

Shrinking staffs and lack of work, however, is not being experienced by all firms. There are some firms that are expanding their offices. Some who are expanding currently are those who are using computers. It is not the "magic" of the machine that is doing this, rather, the computer can be seen as being symbolic of the architect's ability to learn new skills, handle large amounts of data and apply his expertise to the broad areas surrounding that of building. Let us look more closely at this phenomenon.

HISTORY

The coupling of computers with architecture began about ten years ago. While computers had been in use long before that, the period between 1963-1966 was marked by a significant development in computer graphics.

In 1963, direct-view bistable storage tubes were first used in terminals. That year, at the Spring Joint Computer Conference, Timothy Johnson and Ivan Sutherland announced their development of Sketchpad. That program made it possible for the architectural designer to input pictorial data into a computer by drawing on an electronic tablet. The drawing was displayed on a C.R.T. and could be modified with a light pen. The Rand tablet (the device used by Sketchpad) made its appearance at the Fall Joint Computer Conference in 1964.

Responding to the new advances being made, the First Boston Architectural Center Conference, held in December of 1964, had as its theme, "Architecture and the Computer." It was well attended and included many of the persons who were to make advances in computers for architects. Articles linking computers with architecture began appearing in architectural journals and trade magazines. Predictions ranged from computer takeover and subsequent dehumanization of architecture to an office where the computer would be the powerful servant of the architect, reliev-
ing him of all tedious tasks and leaving him free to spend all his time designing and dealing with high level abstractions. The dire predictions of computer takeover have not occurred and fears along that line have been quieted. Articles anticipating the widespread use of computers by the architectural profession however, continue unabated.

The time frame for this transformation was always within the next ten-year range. The ten years are now up. The tone of the articles has changed from enthusiasm about the use of the computers to bewilderment as to why the architectural profession has snubbed the computer, and finally to philosophizing that perhaps architecture and computers are totally incompatible. But what actually is happening?

I do not believe that architecture and computers are incompatible. However, I do feel that many of the people who would like to see computers being used more by architects:

(a) Do not understand what motivates the architect.
(b) Do not have a grasp of the complexity and variety of disciplines which the architectural profession encompasses.
(c) Have no idea as to how architectural offices function and in turn, how they effect how the architect works.

Furthermore, advancement in computer technology takes place primarily in the university, and many of the students are only remotely aware of how architectural offices work. Many of the programs developed in the academic environment are directed more towards the purpose of understanding the discipline of architecture than towards advancing the practice of architecture. I am not here questioning if it could or should be otherwise, but trying to explain why some of the “advances” do not make it to the office.

**HOW WIDESPREAD IS THE USE OF COMPUTERS**

First of all, the architecture profession is a small one. Figures from the 1970 U.S. Census show the comparative size of various professions:

<table>
<thead>
<tr>
<th>Profession</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
<td>Architects</td>
<td>57,081</td>
</tr>
<tr>
<td>Engineers</td>
<td>653,925</td>
</tr>
<tr>
<td>Lawyers</td>
<td>264,752</td>
</tr>
<tr>
<td>Physicians</td>
<td>280,557</td>
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</tbody>
</table>

A tally done by the American Institute of Architects from the state rosters of registered architects lowers the figure to 45,000. (The difference between the two figures can be explained in that “registered” means holding a license to practice, while in the U.S. Census “architect” referred to those people who stated that as their professional status).

While it has been the larger architectural firms that have gone into computers, the profession is characterized by an organization into small offices. Approximately 40 percent of the architectural firms are sole proprietorships. It is estimated that 90 percent of the firms employ six people or less. So the small number of actual users is explained in part by the logistics of the profession.

It is difficult to estimate the actual number of architectural firms using computers. The New York Times (August 29, 1971) estimates that of the 15,000 design firms in this country only 200 use computers. The 15,000 probably represent purely architectural offices and most likely includes the sole proprietorship type of office. To get some idea of the number of large firms, we can refer to The Engineering News Record which publishes a list each year of the top 500 design firms. “Top” refers to dollar billings and the ‘types’ of firm include architect-engineers, engineers-architects, consulting engineers, architects and design-contractors. Of the total number of firms listed about half are involved with architecture.

The issue for May 21, 1970 also included information as to the use of computers by these firms. Excluding design-contractors, “357 of the 460 top design firms reported the use of computers in their operations. Of the 357 firms, 32 percent rent their equipment, 29 percent use a time-sharing system and 13 percent own their own hardware. The balance used varieties of rental and time-share plans.”

While the established pattern has been for the larger architecture firms to be exploring the use of the computer, there is growing evidence that smaller firms are also beginning to utilize computers. One of the reasons for this transition could be the lower cost of hardware. It is now possible to buy a small, but essentially complete computer with one high level language (Basic) for under $10,000. Ten years ago comparable equipment would cost between $30-50,000. Leasing a terminal in 1968 cost $100 per month while now terminals can be had for $50. Time sharing costs ($10-15 per hour) are essentially the same as they were in 1968.

Smaller firms have an easier time than larger ones in adapting to the changes brought about by the introduction of computers. Organizational changes and even new directions are not only simpler to effect, but often the younger members of the firms have less invested in the established way of doing things. There is also evidence that the use of computers by small firms differ from that of large firms. With large firms, computer usage is more likely to be only a small part of the office routine and only used by a small fraction of the staff. When small firms use the computer, the whole office may well be organized around its use. The entire staff is encouraged to put “hands on” the terminal. It is this “hands on” approach that allows an office to explore the tool. This exploration can lead to the application of computer technology to various areas of architecture. The important thing here is that the
people working in the field are the ones who should begin to develop the programs.

In order to better understand how firms make use of computers, the New York Chapter of the American Institute of Architects has recently become interested in what motivates a firm to go into the use of computers. Some of the reasons given were:

1. The approval of the systems approach and the methodology behind computer use.
2. The need to process vast amounts of data in short time.
3. The entry into a new discipline which has not yet developed a methodology.
4. The fascination with the process and a feeling that this must be the future direction for architecture.

This last reason is essentially a commitment to architectural research.

Some of the reasons are frankly window dressing—ways of impressing a client with the firm's grasp of the new technology. But one thing they all have in common is that using computers involves a top management decision. It is the eye of the vice president that this tool catches. It involves top management decisions as to new directions for the firm. Most certainly it will involve a considerable investment and (for the success of the venture) it must have management's continuing active interest, often in the form of a single enthusiastic partner. This last factor explains, in part, why the various branch offices of firms differ widely in computer usage. In one firm, one office uses sophisticated graphics and computer-aided design programs, while in another branch, changes to specifications are done by the architect dictating to a secretary who is seated at a terminal. At one time it was thought that computers would make inroads into the architectural offices by way of the accounting departments. Unfortunately, once into the accounting office, it rarely gets out into the design section.

HOW MIGHT NEW AREAS OF INTEREST INCREASE COMPUTER USAGE?

A new factor which may cause an increase in the use of computers by architects is the entry by the architect into fields which are very compatible with computer usage: information manipulation, numerical calculations, linear programming and graph theory. Because of the decline of building, architects are exploring some of the other areas which are related to the building process. The architect is now looking into the processes which are active before the building is designed, such as economic analysis, building programming, establishment of standards; processes active after a building is built, such as evaluation; and processes involving not-building, such as renovation. "Programming" for an architect is the assembly of the detailed requirements for a project into a coherent form, not the writing of computer procedures. Some of the more specific areas where computers are beginning to be of assistance are the following. It will be interesting to see if in moving into new areas, the architect accepts the new technology.

LIMITED RESOURCES PLANNING

A decade ago 'limited resources' was a concept that architects did not have to concern themselves with. The recognition that earth's resources are finite demands that the profession deal responsibly with energy, time, money, land and space. Today it is irresponsible for an architect to plan hospitals without taking into consideration the logistics of health care delivery, population trends and availability of technical staffing. There are programs utilizing the techniques of linear programming which are useful in this area. They allow the architect to consider the effects of a number of variables operating at the same time to arrive at an optimum solution for that situation. Graphic output aids in understanding how the various factors operate.

ECONOMETRIC MODELS

Just as architects use physical models to explore design solutions, they will also use econometric models to help them with the many other factors influencing design decisions. Life-cycle costing, value analysis and cost benefit analysis are three current methods in favor with both the architect and his more sophisticated client. Computer techniques are extremely useful here because of the iterative process of the analysis. The analysis may cover a wide range of items, such as building components, systems, services and social benefits. Solutions are arrived at by combinations and re-combinations of the variables. If many items are to be considered, the analysis by hand is extremely tedious and slow.

THEORY OF DESIGN

Not a new area but clearly one of the more favored. The push to demystify the design process and to understand how the architect evolves his solution is more in the purview of the architect-computer-researcher than of the architect-teacher. In order for computer programs to be able to assist the architect they must be designed with an understanding of the process which they are assisting. A comprehensive study of the design activity in architecture has been carried out in the Department of Design Research at the Royal College of Art in London by a team of researchers headed by Patrick A. Purell. The study, "Analysis of Architectural Design Activity in the Working Envi-
Environment" attempts both to develop a model of design activity and to evaluate computer-aided design techniques. The study begins to define clearly the points in the design process when the architect needs information and how he incorporates various types of information into his "internal representation." Insights derived from work done on design corroborate the architect's feeling as to the importance of this area. Design and planning may comprise about one half of the total time of the entire job. In complex building types, such as hospitals, economies in design and planning time can save a building from being obsolete upon completion.

Attempts to deal more objectively with the design process are being made by design offices. Governmental agencies and corporate clients, with increasing frequency, are asking for an "objective" analysis of the design. Cluster analysis and hierarchical composition, and resolution are some of the techniques being used to arrive at decisions. However, sometimes what is passed off as an objective scientific analysis of the problem is simply putting numbers on subjective decisions.

BUILDING PROGRAMMING

Architectural firms which have experience in a particular building type are eminently qualified to write programs for that type of building. Most firms have not developed techniques for saving and reusing their data and so, much of their valuable experience is only partly carried over to the next job of type.

Non-architectural firms which have become involved with preparing "Building Programs" have developed sophisticated data gathering and data processing techniques. Architectural firms, in general, have been slow in utilizing these techniques. And yet, the application of these techniques could amplify the architect's experience into a powerful programming tool. There is also an increasing demand for pre-programming analysis of data relevant to the proposed project and this analysis is becoming so complex that perhaps computerization is the only rational way to do it. Feasibility studies are also used to make some assessment before proceeding to the long and expensive process of writing a "building program."

FACILITIES MANAGEMENT

Different from construction management and more suited to the architectural firm with some expertise in general management, this area covers the comprehensive management of the existing and future building activity of a large facility. Real estate, financial and building cost data are manipulated in various ways in order to arrive at a most beneficial mix for the client. Again, it is necessary to explore a large range of alternatives.

Architecture contains a vast assortment of skills and disciplines which are necessary to produce a building. As the profession adapts to new needs, new skills will have to be acquired. The pattern of growth is outward, in the direction of higher order generalities such as the understanding of the socio-economic processes which affect the building, rather than towards areas which are more specific and circumscribed. Perhaps this fundamental outlook underlies the fact that there has been no great movement by architects, even in a time of unemployment, to go into the field of engineering.

ARCHITECT-COMPUTER INTERFACE

In designing an architect-computer interface one should be aware that the architect feels differently about different areas.

(1) There are things an architect cannot do or cannot do well, but which he is interested in doing.
(2) There are things which he doesn't want to do,
(3) There are things which he doesn't want to do—but he has to.
(4) There are things he does well in which he feels he doesn't need any help.

1. Things an architect cannot do or cannot do well, but which he is interested in doing. Computer assistance in this area is welcomed by the architect because with it he can attempt areas previously inaccessible. An example of this type is Christos Tountas' 8-dimensional tent construction program. In it the designer specifies the anchor points in plan and elevation and the computer generates the shape of the tent in which the stresses will be equally developed. The program will then provide load analysis and coordinates of all the nodes. The designer can, in addition, specify various elastic properties to the edge cables and because the system is interactive, the computer will redraw the resultant shape of the tent. This technique for designing tents far surpasses the method presently used—the construction of actual models.

Any program which allows an architect to design curved forms as easily as he does in straight lines would free him from the constraints of his straight line geometry. It would assist him in conceptualizing shapes and spaces which are currently too difficult to draw.

Simulation programs showing movement of material and people through a building would also be useful. The architect, while he can visualize space easily, finds it difficult to visualize continuing processes through the space. Since he must make design allowances for them, visual representation can be very helpful in understanding the problem.

2. Things which he doesn't want to do. If a program is provided that would simplify these tasks he probably would still rather someone else did them. An ex-
ample of this are programs for structural analysis. Regardless of how easy it becomes, on any large project the architect will still want the engineer to do it.

3. Things which he doesn't want to do—but has to. These are areas of his responsibility like code compliance and specification writing. The simpler the process, the better. Moreover, it is not what the master-builder will get involved with as much as the guy in the back room. Furthermore, for a firm to buy a computer program, it will have to be cost competitive with their consultant.

4. Things which he does well, such as design, and feels he doesn't need any help—in fact, he is competitive with the computer. However, since these are areas which he enjoys he is willing to experiment with computer assistance providing he is clearly the boss and sets the pace. He is highly critical of the system design and is intolerant of frustration. Because he builds up his design on consecutive inputs—turn-around time, machine response must be fast in order to be useful. This usually works best in interactive systems. Examples of this area are the various computer-aided design programs. They can range from a printout of the dimensions to a design solution to interactive design in three-dimensions with color and perspective, time sequenced.

Drawing is a relevant step in the architect's strategy for evolving a design solution because he thinks graphically. He literally "sees" his solution. It is his form of data compression, data manipulation and data transmission. That is why computer use for the architect must involve graphics. It can be simple tables, charts, and even simple line drawings will do. Because the architect can visualize easily, it is not necessary for an object to be colored and shaded before he finds it meaningful. Because the embellishments are not essential the architect is not likely to pay for it for himself. The trimmings are more appropriately saved for the client. But there is a great difference between designing a computer program for an architect and for his client.

SCHOOLS

The America Institute of Architects held a seminar for architectural students on The Changing Role of Architecture and invited the deans of two eastern schools. Their answers to the question "What are you trying to teach the students?"—one answered, "To dream," the other "To think." Needless to say, in these schools there is little emphasis placed on the use of computers in architecture. There are schools where students are taught to think and dream and to use computers. To visit such a place is an electrifying experience. The Architecture Machine at M.I.T., under the aegis of Nicholas Negroponti is one such place. Students are expected to investigate, explore and contribute to the new technology. These graduates unfortunately find little place for their skills in the architecture profession and often go back into the university or to other industries and so the dissemination of new techniques slowly reaches the profession.

CONCLUSION

And so . . . how is the use of computers coming along in the field of architecture? Slowly, and for good reasons.

First, it is a complex field which covers many disciplines and it is difficult to know which parts will take to computerization.

Second, the computer people have not understood the architect. They have not amplified his strengths nor have they mitigated his weaknesses. They do not know how to bring the computer to him nor how to bring him to the computer. They don't even know of what stuff his dreams are made.

Third, progress in computer technology, for the architect, has been mostly in the universities and in the larger firms. The universities are often not aware of the real-life problems of the architect. The larger firms are too few in number and have too often been content with the computer's power to impress, rather than its power to compute.

But, the smaller firms, of which there are many, are beginning to get into the picture. After all, one can now buy a computer for the cost of a sports car. Hopefully, these small firms will contribute to the use of computers because more people, who are architects, will be using them. In addition, the new areas into which the architect is heading, are eminently suited for computer assistance and indeed many of these areas have been substantially touched by computers. Under the impetus of becoming extinct, there will be architects who, with the help of computers will finally make it into the 20th century.

APPENDIX

A selected list of articles dealing with computers and architecture. Most of them have appeared in architectural journals. They are listed chronologically because it provides an historical overview of architectural interest in computers and computer related areas.

1969 Farrell, P. B., Jr., "How Computerized Land Development

SYSTEMS

Computer Systems
Systems Management
Networking
Business and Industry Systems