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Authors

Schuman, J.
Ward, G.

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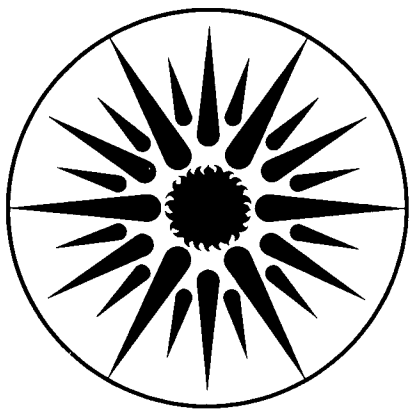
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The Practical Computer in Design

Jennifer Schuman and Gregory Ward
Windows and Lighting Program
Applied Science Division
Lawrence Berkeley Laboratory
1 Cyclotron Road, Building 90, Room 3111
Berkeley, California 94720

July 1990

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The Practical Computer in Design

Jennifer Schuman and Gregory Ward

Lawrence Berkeley Laboratory
Berkeley, CA 94720 U.S.A.

Abstract

Electronic information processing is becoming a necessity in today's complex design environment, but what is an appropriate role for the computer in the design process? Computation should be applied throughout all design phases, but practicing designers today rarely use computers beyond simple word processing and drafting tasks. While many design tasks are poorly matched to the computer, other pragmatic and productive avenues remain unexploited. We discuss the need to recognize which elements of the design process are most suited to computer assistance. The authors define a role for the computer as an objective assistant to the designer, and discuss practical approaches in two application areas for computers in design: design simulation and resource information management.

Introduction

Today's computer is not being fully exploited in design. While many software applications exist for designers, their influence in design is limited. Current applications are generally not integrated with each other, have limited access to information, and are useful only in the late stages of the design process or for non-design tasks such as word processing. Computers hold a haphazard, suboptimal place in design, and they rarely affect design decisions, especially decisions made in the early conceptual phases of the design process. In spite of the difficulty in developing computer applications for all but the most repetitive and menial design tasks, we believe there are tremendous missed opportunities for applying the computer to design. To exploit the computer's potential requires a recognition of its best fit in the design process. This paper will address the most practical development opportunities within *existing* knowledge and technology, with respect for the difficulties of matching algorithms to design tasks.

Design is inherently difficult to describe to a computer. It is a poorly understood, unformalized process full of characteristics considered essentially *human* in nature and which have eluded capture by programmers. In fact, computing technology has not met the promises made by early developers and has not impacted design as originally predicted by many enthusiasts (Stevens, 1990). Some of the firmest believers have subsequently faced disillusionment when confronted with the constraints of the real world (Bazjanac, 1975; Negroponte, 1975), much like artificial intelligence began to fail in meeting expectations when it became apparent that common sense is not easily rendered to a computer (Dreyfus, 1979).

The lack of success in computer applications for design is most often attributed to user resistance, insufficient research, and inadequate technology. These are important factors, but we believe the primary issue is the lack of attainable and appropriate goals. What are the attainable goals for the computer in design? What parts of design can be computed, and what parts would we rather save for ourselves, regardless? These questions have been addressed by many researchers, but the

answers are not forthcoming (Kalay, 1987). Scientists continue to struggle with the computability of thought (Churchland & Churchland, 1990; Searle, 1990) and with design optimization methodologies (Radford & Gero, 1988) in pondering the role of the computer 100 years from now. We prefer a practical approach that is both appealing and suggests an immediate course of action. There are many parts of design we already understand well enough to implement on the computer, but we have not spent the time to do so. Let us develop computer applications in these areas first, while continuing to rely on human designers to do what they do best. The authors highlight two areas of currently available computer technology that, with proper development, could offer appropriate assistance during many design tasks.

Design Simulation

One of the most promising applications of computers in design assistance is simulation. Computer simulation takes the description of a system and predicts its behavior under a given set of circumstances. Successful applications of simulation fulfill the following requirements:

1. The behavior of individual components and their interactions must be well understood.
2. The system must be described in sufficient detail.

With the ability to predict the behavior of most well understood systems, the potential of computer simulation for design analysis is tremendous. However, a human is still needed to generate the initial design, to interpret simulation results, and to apply this interpretation to design modifications. It is not currently possible, nor may it ever be, for a computer to interpret simulation results automatically. Interpretation requires the weighing of multiple concurrent and conflicting criteria, many of which are context-dependent and unquantifiable. There is no formula for human perception, so there is no way for a computer to determine the success of a design from a human standpoint. It is even difficult for a computer to determine what part of a simulation is useful and what is irrelevant or wrong. Computer simulation is therefore most useful as an aide to a human designer, not as a replacement.

Simulation could be a powerful design tool, but it is generally used too late for major design changes, is often too costly, and requires specialized expertise to run and interpret. To maximize the ability of the designer to interpret and act on simulation results, we must direct our attention towards more convenient and natural computer-human interactions. The current emphasis on simulation techniques and computer speed is like adding horsepower to a gas-driven shopping cart; what it really needed is a seat and a steering wheel! Although the technology exists to dramatically improve the interface to simulation, research is only beginning in this direction. For example, so-called "virtual realities" are being developed that provide real-time sensory feedback to a computer user wearing stereo earphones and a visor. Similar technology might permit designers to experience their systems before they are built, and modify them interactively. This is not such an ambitious goal. Such natural interfaces are almost within reach of current technology.

Figure 1 shows a page of typical output from a common daylight simulation program. The results are given numerically, and require an expert to interpret. Figure 2 shows the lighting simulation output from a different program. Although this image contains much more information than the numerical output, it can be interpreted even by a novice. The difference is in representation of the data, and while lighting simulation is an obvious candidate for visualization, virtually any calculation that produces meaningful results can be presented to a designer in a more intuitive format than numeric representation, for an easier and more direct interaction between the computer and the designer.

```
**************************************************************************
* DATA FOR WORKING SURFACE NODES; I=SURFACE, K=NODE-NO.                   *
*       X,Y,Z=COORDINATES,                                                *
*       S=ILLUMINANCE FROM EXTERNAL SOURCES (FOOT-CANDLE)                 *
*       R=INTERNAL REFLECTED COMPONENT (FOOT-CANDLE)                      *
*       I=TOTAL ILLUMINANCE (FOOT-CANDLE)  D=DAYLIGHT FACTOR (PERCENT)   *
**************************************************************************
```

*K		1	2	3	4	5	6	7
I*								
9	X	.20	.60	1.00	1.40	1.80	2.20	2.60
	Y	2.92	2.92	2.92	2.92	2.92	2.92	2.92
	Z	.80	.80	.80	.80	.80	.80	.80
	S	42.13	53.57	69.53	92.53	127.91	181.98	269.82
	R	198.61	219.61	236.09	249.67	265.87	281.22	291.33
	I	240.74	273.18	305.62	342.20	393.77	463.21	561.15
	D	14.71	16.69	18.68	20.91	24.06	28.31	34.29

*K		11	12	13	14	15	16	17
I*								
9	X	.20	.60	1.00	1.40	1.80	2.20	2.60
	Y	1.75	1.75	1.75	1.75	1.75	1.75	1.75
	Z	.80	.80	.80	.80	.80	.80	.80
	S	59.26	77.70	104.27	143.57	203.11	294.13	4635.41
	R	230.97	252.62	261.63	273.88	289.67	304.62	313.62
	I	290.22	330.32	365.90	417.45	492.78	598.75	4949.03
	D	17.74	20.19	22.36	25.51	30.11	36.59	45.28

*K		21	22	23	24	25	26	27
I*								
9	X	.20	.60	1.00	1.40	1.80	2.20	2.60
	Y	.58	.58	.58	.58	.58	.58	.58
	Z	.80	.80	.80	.80	.80	.80	.80
	S	63.02	81.73	107.96	145.60	199.43	282.65	4612.68
	R	215.14	233.67	250.24	265.71	286.98	312.99	347.31
	I	278.15	315.40	358.20	411.31	486.41	595.63	4960.00
	D	17.00	19.27	21.89	25.14	29.72	36.40	45.95

Figure 1: Simulation output from *Superlite* (Lawrence Berkeley Laboratory).



CBB 878-6587

Figure 2: Simulation output from *RADIANCE* (Lawrence Berkeley Laboratory).

Resource Information

Information auxiliary to the specific design at hand is important through all stages of the design process. Designers turn to sources like guidebooks, catalogs, photographs, past projects and colleagues for help. Resource data used during design comes from a large, fragmented, non-standardized, and disparate base (Burnette, 1979). The computer is a natural solution for this data base management problem, but we must first understand a designer's interaction with resource data.

How, when and why do we look things up, and how do we interpret what we have found? This will likely never be formalized beyond very specific, defined queries such as checking building code requirements . For example, can we describe our method in a search for inspiration? It is distinctly context-specific and subjective to respond to design-relevant information, to translate visual information into meaningful entities, to assign value to the entities, and to pick out specific pieces that matter. What a computer can do is present information and leave the associations to the viewer.

We thus desire a neutral computer resource system that allows the open and undefined manner that people often use to interact with data, a process quite unlike the structured data queries generally required by conventional databases. We don't always know what we're looking for when "browsing", nor do we always know when we've found it. Design has been described as inquiry, a continuous exploration of learning and discovery (Lawson, 1980; Lyndon, 1982) that eventually reaches its conclusion when the designer has run out of time or money. A resource system enters a new dimension of interactive possibility when easy and fluid exploration through it is allowed.

Storing design resource data electronically allows an exponential leap in access speed and in the efficiency of search, query and data organization over traditional storage mechanisms like a messy desk top, file cabinet, or human memory. Computers do best what bores people the most (Wilson, 1987), and they do it better.

Recent shifts in the electronic environment show a greater awareness of the user's natural traits. For example, multi-sensory information can now be conveyed with equipment and software so sophisticated that simulation and reality begin to blur in their distinction. We have instant access to photo-realistic simulated images, photographic images, moving images, and sound, all available for digital manipulation. We can now electronically capture a range of data never before possible, broadening the kind of design resource information accessible through the computer.

We also now have new ways to store data that allow free browsing without the loss of structured data base advantages. For example, recent commercial software applications have appeared using a *hypertext* data model, a concept based on non-sequential linked nodes of information storage. In contrast with the traditional fixed sequence structure of printed text or file systems, the model of a linked-nodes network is especially appropriate for the organization and manipulation of irregularly structured information (Halasz, 1988), which makes it an ideal model for the flexible design resource data base designers use.

The combination of a hypertext information structure with multimedia presentation techniques yields *hypermedia*. The technologies for hypermedia are commercially available and are being enthusiastically explored across many disciplines. The first tools have thus arrived for the creation of an architectural resource data base powerfully enhanced with the computer, where a broad range of data is available in a broad range of media, equipped with all of the sophisticated management features we expect in electronic data bases yet allowing the user to define the nature of the interaction (Figure 3).



CBB 901-57

Figure 3: Prototype hypermedia workstation developed at the Lawrence Berkeley Laboratory as an exploration into next-generation electronic media for technology transfer to the architectural community. A resource data base in the topic Daylighting Design Issues has been prototyped in hypermedia, and includes building case study documentation, simple conceptual design aids, and daylighting conceptual explanations.

Conclusion

We have described design simulation and resource information management as two design tasks that are appropriate and practical choices for improved computer applications, and we have presented examples of our own efforts towards these ends. These are research areas less glamorous than artificial intelligence, optimization and automation, but we feel they are more profitable and more practical for designers.

We are just beginning to explore two other areas of interest in our vision of a better computer support environment for designers. Expert systems, while not promising for general design problems, do offer potential in very limited domains where the expertise is explicitly representable and there are few variables. Extremely specialized tasks, such as sub-system analysis or component selection, could be addressed through computerized expertise. Additionally, the computer can serve as central information manager through major design projects, facilitating communication between players thousands of miles apart, automatically archiving information flows, and thus maintaining project integrity.

All work towards improving the use of computers by designers suffers from a general lack of standards and direction in research and in industry. Designers are overloaded with proprietary software, and the trend shows only minimal signs of slowing with recent standards for CAD geometric models. We conclude with a plea that defining an appropriate role for computers in design is a two-stage process: first individual software packages must serve the practical and natural needs of designers, and then multiple packages must be integrated with each other. Natural human interfaces and time-saving software links are the practical direction for today's research and development in computer applications for design.

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LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
INFORMATION RESOURCES DEPARTMENT
BERKELEY, CALIFORNIA 94720