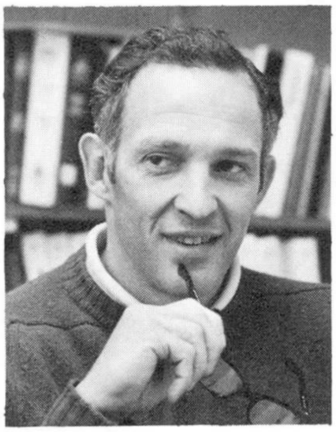
Impact of Computer Graphics on Architecture and Engineering

Implications de l'infographie pour l'architecte et l'ingénieur

Einführung von Computer-Graphik in der Architektur und im Bauingenieurwesen

Donald P. GREENBERG
Prof.
Cornell University
Ithaca, NY, USA



Dr. Donald Greenberg is Director, Program of Computer Graphics and Computer-Aided Design Instructional Facility at Cornell University, Ithaca, NY. He is Professor in the field of Architecture, Structural Engineering and Computer Science.

SUMMARY
The presentation illustrates many uses of computer graphics which will affect the architecture and engineering professions. The illustrations are examples of pilot programs and research projects which have been conducted at Cornell's Program of Computer Graphics. Difficulties with using this enormously powerful technology are described, as well as the changes which are currently occurring within the computer industry. These changes will result in new, single-user work station environments for the designer and engineer. Some remarks are presented on the effect that these technical advances may have on both professions.

RESUME
La présentation porte sur l'illustration des usages de l'infographie qui sont en mesure d'affecter les professions d'architecte et d'ingénieur. Elle se réfère aux projets pilote et aux recherches qui ont été conduites dans le cadre des actions entreprises à Cornell dans le domaine de l'informatique graphique. Les difficultés de mise en œuvre de l'énorme potentiel technologique dans ce domaine sont mises en évidence, ainsi que la rapidité de l'évolution dans l'industrie de l'informatique. Cette évolution conduit au développement de stations individuelles destinées au concepteur.

ZUSAMMENFASSUNG
Es werden verschiedene Computer-Graphik-Anwendungen beschrieben, welche den Beruf des Architekten und Bauingenieurs in der Zukunft beeinflussen werden. Die Beispiele stammen aus Pilotstudien und Forschungsprojekten, die an der «Cornell's» Schule für Computer-Graphik durchgeführt wurden. Schwierigkeiten, die bei der Verwendung solcher wirksamen Technologien entstehen, werden beschrieben und es wird auch über Veränderungen berichtet, die gegenwärtig in der Computer-Industrie vor sich gehen. Als Resultat dieser Veränderungen wird eine «single-user» Arbeitsplatz-Umgebung für den Ingenieur und Architekten hervorgehen. Zum Schluss werden einige Bemerkungen über die Auswirkung dieser technischen Fortschritte bei beiden Berufen gemacht.

I. INTRODUCTION

During the past two decades, a number of important technological advances have occurred in the computer industry and structural engineering, and these advances have changed our methods for analysis and design. Finite element analyses are now standard procedures which have been widely accepted. Unfortunately, current implementation of these techniques require our spending excessive time on the wrong aspects of the problem.

The time required to accurately define the information necessary for a computer analysis is large. Probably, the major portion of the typical cost of a finite element analysis is in the input task. An even worse problem exists in the interpretation of the results. One sometimes spends many hours searching through pages of computer output trying to understand and interpret the analysis. The time spent on the conceptual and creative part of the process has unfortunately been proportionally reduced.

On the other hand, despite the computerization in structural engineering, the architecture profession has not yet leaped into this technological foray nor taken advantage of these technological advances. There are several reasons for this.

- The capital investment required to start is still excessive.
- The structure of the architecture industry is fragmented. Drawings are copied, consultants perform their tasks independently, and communication between disciplines of the building process is poor.
- It takes a long time to attain leadership roles since the profession is historically based on apprenticeships. Thus, principals of firms, who earned their positions over many years, have not been educated in computer technology.
- Perhaps, most importantly, there exists a natural and skeptical resistance to the intrusion of a powerful machine technology into a heretofore aesthetic domain.

Unfortunately, the net result of the traditional approach with its inefficient labor-intensive procedures, is also the wrong allocation of time. Too much effort and cost is spent in the production of drawings when compared to the time allotted for design concepts.

Now, however, several factors imply that the architecture profession is ready to also accept the new technology.

- Skilled draftsmen are difficult to find, and the production of drawings is both time-consuming and expensive.
- The cost of computing is decreasing exponentially.
- New architectural employees have grown up in the era of television and video games, and are no longer afraid of the technology.
- The mystique of the computer is attractive to clients. Computer-aided design systems are now being used as a sales tool to obtain new commissions.
- Lastly, at least in the United States, some of the major clients such as the government and the aircraft industry now require machine-readable data in their contract specifications.

All of this has led to a renewed interest by the architecture profession in the computer-aided design field. Market surveys now predict that the fastest-growing segment of the entire computer-aided design industry will be in the architecture/engineering profession.

It is my belief that the future of the design fields, both engineering and architecture, will rely on the uses of INTERACTIVE COMPUTER GRAPHICS and information will be defined pictorially. We live in a visual world. Our ability to comprehend graphical information far exceeds our ability to understand verbal or numerical information. In short, "a picture is worth 1024 words!"

It is important to emphasize the meaning of the word "interactive" in computer graphics. When graphical operations and commands are specified, it is necessary to have response times fast enough to provide a continuous communication dialogue with the user. For three-dimensional investigations or dynamic problems, continuous motion displays are necessary. In order to fully understand complex geometries, one would like to simulate walking around the structure, like taking a model in your hands and turning it around to examine it. This requires the rapid generation of perspective images, maybe 30 or 40 times per second, in order to imply motion. Color is also useful, not only to provide a realistic three-dimensional image, but to display results.

Some of these concepts will be illustrated by showing you the results of several research projects which have been conducted at Cornell's Program of Computer Graphics.

II. VISUAL PRESENTATION - SLIDES

III. CURRENT TRENDS IN COMPUTER-AIDED DESIGN EQUIPMENT

It is useful to review the recent trends in computer-aided design. Ten years ago, most computer-aided design systems started with large time-shared computers, many users, a common database, and generally poor response. The poor response occurred for several reasons.

- It was difficult for a single user to get the machine's attention in a time-shared environment.
- The amount of data required to generate a picture is very large, and the "bandwidth" required to transmit this data rapidly was not available.
- Furthermore, the cost of vector refresh display systems was too expensive.

To eliminate some of these deficiencies, a new line of computer products became available in the mid-1970's. Graphic display stations, using raster technology, were introduced. These devices have the advantage of being primarily dependent on the cost of computer memory which is decreasing very rapidly. Furthermore, they also provided the unique opportunity for displaying color at little additional cost. A great amount of intelligence was also put into the display terminals. Capabilities for dynamic rotations, perspective image generation, clipping, vectorization, filling polygonal areas, etc. were all introduced. By having these operations performed locally, the amount of data which is necessary to send from the host computer to the display device is substantially reduced and therefore graphic response times were improved. However, the basic problems related to time-shared environments are not solved.

Today, new devices called "ENGINEERING WORK STATIONS," are being introduced. These consist of 32-bit microprocessors with virtual memory addressing capability. Physical memories may range from one to four megabytes, with mass storage devices of tens or hundreds of megabyte capacity. These "work stations" are sufficiently large, in terms of their storage capacity and their speed, to handle real-world problems. A number of computer companies currently market these systems. Two specific characteristics related to these work stations are important to emphasize. The first is that their networking capability is absolutely essential, and must be incorporated into their hardware designs and operating systems. Almost all manufacturers are leaning toward networking architectures which will transmit data in the range of ten megabytes per second. This means that users on the network can share resources, and even have processing accomplished on idle components, with results returned to the user's station. Perhaps even more important is the fact that these new "work stations" are using raster displays, where the images are refreshed directly from the local machine memory. Therefore, one is no longer bandwidth-restricted when data is sent from the processor to the display device.

These new systems will have a tremendous impact on the engineering and architecture professions. It is my contention that, in this decade, all professional engineering and architecture firms must move in this direction. The designer of the next decade will have his own machine and work station, using interactive graphics to solve his problems. Since the systems will be inexpensive and modular, it will be easy for everyone to get started, incrementally building up their private networks. The uses of graphics will be paramount, since the transmission and understanding of information is so fast. Color will be available for free, and thus will be greatly used to interpret results.

Aside from the descriptions of how the technical uses will change, a greater impact may be on the structure of the two building professions. For the first time, small firms will be able to afford the luxuries which previously only larger companies could attain. For the first time, the two and three person firms will be able to bid for the same jobs that previously were only the domain of larger companies. This will clearly make the industry more competitive. But also, one hopes, this will once again place a greater importance on the creativity and design capability of the individual and, hopefully, improve the quality of our built environment. Thank you for your attention.

Leere Seite
Blank page
Page vide