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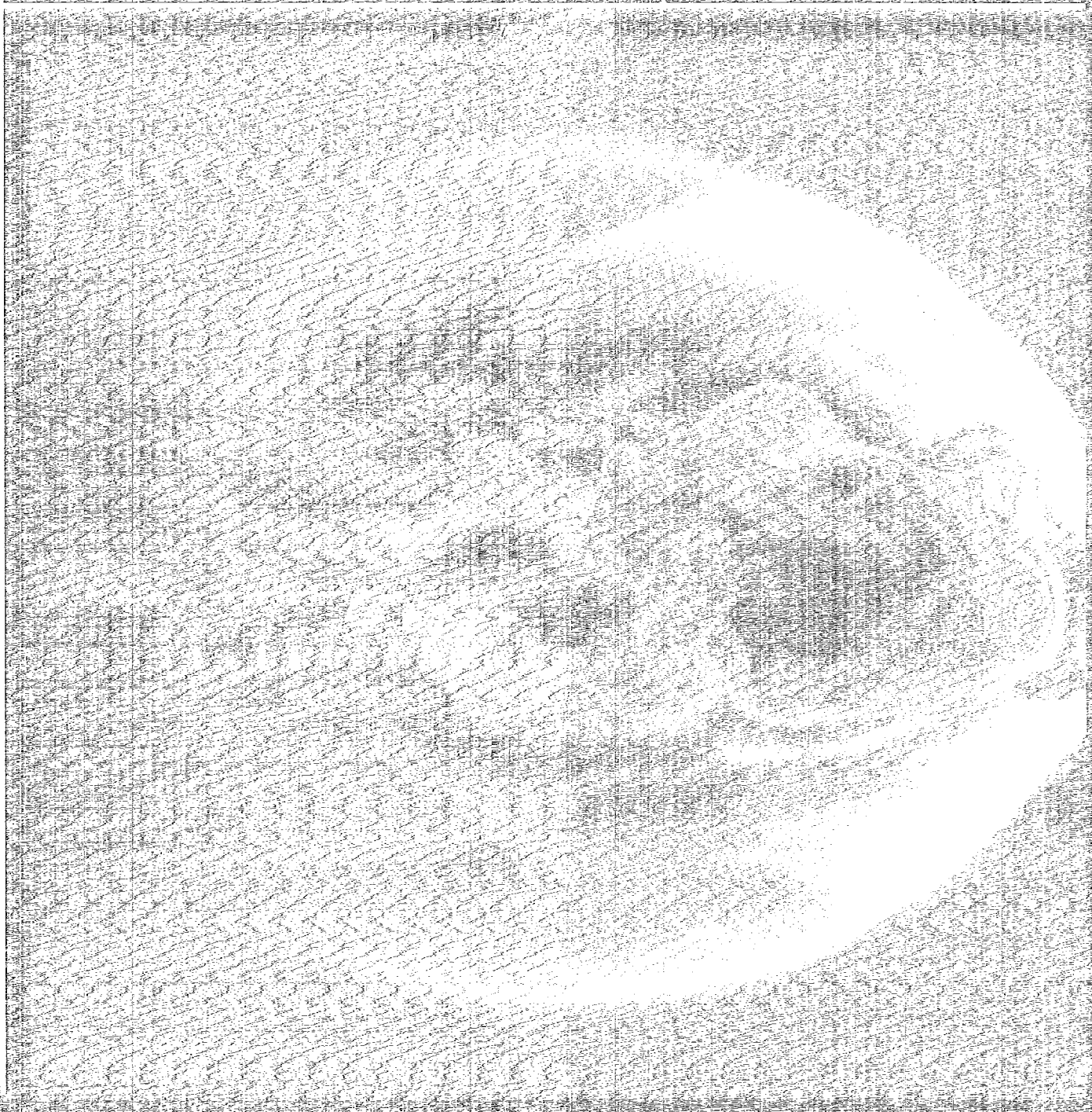

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Visualization in Scientific Computing

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This report is accompanied by two hours of videotape published as issues 28 and 29 of the **SIGGRAPH Video Review**. See appendix E in this report for descriptions of the contents. Videotapes are available in either VHS or 3/4" U-Matic formats.

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Panel Report on Visualization in Scientific Computing

Visualization in Scientific Computing (ViSC) is emerging as a major computer-based field, with a body of problems, a commonality of tools and terminology, boundaries, and a cohort of trained personnel. As a tool for applying computers to science, it offers a way to see the unseen. As a technology, Visualization in Scientific Computing promises radical improvements in the human/computer interface and may make human-in-the-loop problems approachable.

Visualization in Scientific Computing can bring enormous leverage to bear on scientific productivity and the potential for major scientific breakthroughs, at a level of influence comparable to that of supercomputers themselves. It can bring advanced methods into technologically intensive industries and promote the effectiveness of the American scientific and engineering communities. Major advances in Visualization in Scientific Computing and effective national diffusion of its technologies will drive techniques for understanding how models evolve computationally, for tightening design cycles, integrating hardware and software tools, and standardizing user interfaces.

Visualization in Scientific Computing will also provide techniques for exploring an important class of computational science problems, relying on cognitive pattern recognition or human-in-the-loop decision making. New methods may include guiding simulations interactively and charting their parameter space graphically in real time. Significantly more complexity can be comprehended through Visualization in Scientific Computing techniques than through classical ones.

The university/industrial research and development cycle is found to be inadequate for Visualization in Scientific Computing. The programs and facilities are not in place for researchers to identify and address problems far enough in advance, even though the emerging discipline of Visualization in Scientific Computing is found to be critically important to a portion of the country's domestic and export trade threatened by foreign competition. At the present rate of growth, the capabilities of networks, displays, and storage systems will not be adequate for the demands Visualization in Scientific Computing will place on them.

The gigabit bandwidth of the eye/visual cortex system permits much faster perception of geometric and spatial relationships than any other mode, making the power of supercomputers more accessible. Users from industry, universities, medicine and government are largely unable to comprehend or influence the "fire hoses" of data, produced by contemporary sources such as supercomputers and satellites, because of inadequate Visualization in Scientific Computing tools. The current allocation of resources at the national supercomputer centers is considered unbalanced against visualization, in competition with demands for more memory and disks, faster machines, faster networks, and so forth, although all need to be improved.

The Panel recommends a new initiative in Visualization in Scientific Computing, to get visualization tools into "the hands and minds" of scientists. Scientists and engineers would team up with visualization researchers in order to solve graphics, image processing, human/computer interface, or representational problems grounded in the needs and methods of an explicit discipline. The expectation is that visualization tools solving hard, driving problems in one computational science would be portable to problems in another. Proposals would be peer reviewed, and awarded for both facilities and projects at national supercomputer centers and elsewhere. Other agencies of government are encouraged to recognize the value of Visualization in Scientific Computing in their missions and support its development accordingly.

Applying graphics and imaging techniques to computational science is a whole new area of endeavor, which Panel members termed Visualization in Scientific Computing.

Preface

Panel on Graphics, Image Processing and Workstations

In October 1986, the Division of Advanced Scientific Computing (DASC) of the National Science Foundation (NSF) sponsored a meeting of a newly-organized *Panel on Graphics, Image Processing and Workstations* to provide input to DASC on establishing and ordering priorities for acquiring graphics and image processing hardware and software at research institutions doing advanced scientific computing, with particular attention to NSF-funded supercomputer centers. Supercomputer centers had been requesting funds to provide graphics hardware and software to scientific users but, in point of fact, existing tools were not adequate to meet their needs.

Computer graphics and image processing are within *computer science*; the application of computers to the discipline sciences is called *computational science.* Applying graphics and imaging techniques to computational science is a whole new area of endeavor, which Panel members termed *Visualization in Scientific Computing.*

The Panel maintained that visualization in scientific computing is a major emerging computer-based technology warranting significantly enhanced federal support. From the Panel's first meeting came two principal recommendations. It was suggested that the NSF hold a workshop with other government agencies in order to generate a formal summary of the field, and that the NSF establish a new initiative on Visualization in Scientific Computing (ViSC).

Workshop on Visualization in Scientific Computing

The *Workshop on Visualization in Scientific Computing,* held February 9-10, 1987 in the NSF Board Room in Washington D.C., and co-chaired by Panel members Bruce H. McCormick and Thomas A. DeFanti, brought together researchers from academia, industry and government. Computer graphics and computer vision experts analyzed emerging technologies, and federal agency representatives presented their needs and interests. Scientists representing physics, mathematics, chemistry and medical imaging showed examples of their computer-generated imagery using film, videotape and slides. A presentation on Japanese visualization research, a tutorial on state-of-the-art computer graphics animation research, and an overview of commercially available hardware and software rounded out the agenda.

Initiative on Visualization in Scientific Computing

This report presents the findings and recommendations of the Panel for a new initiative in Visualization in Scientific Computing. Much of the impact of visualization, as applied to scientific and engineering research, cannot be conveyed in printed matter alone — so this document is accompanied by a videotape that illustrates pioneering efforts in visualization today.

Visualization in Scientific Computing (ViSC):

Definition, Domain and Recommendations

We believe advanced capabilities for visualization may prove to be as critical as the existence of supercomputers themselves for scientists and engineers.

Visualization Benefits

This report proposes solutions to an important set of foundational problems. These solutions, if addressed in a methodical, sustained way, offer many benefits to our scientific community at large.

Integrated set of portable tools

Solving problems relies on the efficacy of available tools. Each important client of visualization capabilities, notably industry and mission agencies, has an interest in better hardware, software and systems. We believe that their future needs will be served better if potential technological barriers and bottlenecks are confronted now in a collaborative program.

Scientific progress and leadership

Scientific breakthroughs depend on insight. In our collective experience, better visualization of a problem leads to a better understanding of the underlying science, and often to an appreciation of something profoundly new and unexpected.

Scientific productivity

Better visualization tools would enhance human productivity and improve hardware efficiency. We believe advanced capabilities for visualization may prove to be as critical as the existence of supercomputers themselves for scientists and engineers.

Standardization of research tools

If properly designed and structured, tools and interfaces developed for one discipline science or engineering application would be portable to other projects in other areas.

Safeguard American industrial competitiveness

Our country's technology base, certain mission programs and many high-technology companies will depend increasingly on visualization capabilities. Our industrial competitiveness also has implications for national security. Without a coherent initiative, foreign commodity manufacturers may catch up with American industry from the low end and dominate it.

Making advanced scientific computing facilities useful

The use of today's *advanced* visualization capabilities will eventually spread to industry, medicine and government — beyond the few universities where these capabilities exist today. Supporting a relatively modest but appreciable ViSC initiative now could make supercomputer power usable by these extended communities 5-10 years sooner.