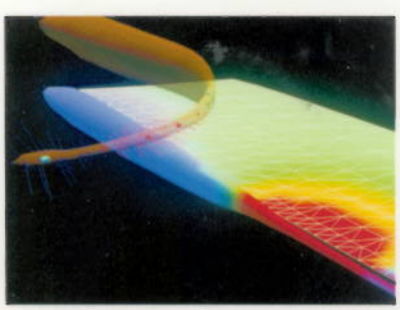
ELECTRONIC THEATER

ART AND DESIGN SHOW

SIGKIDS

THE EDGE

VROOM



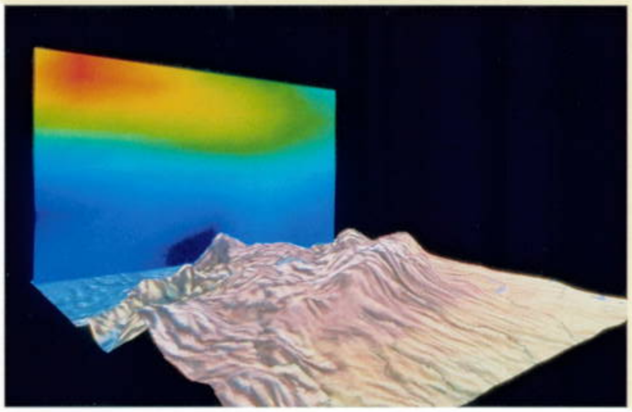
VISUAL PROCEEDINGS

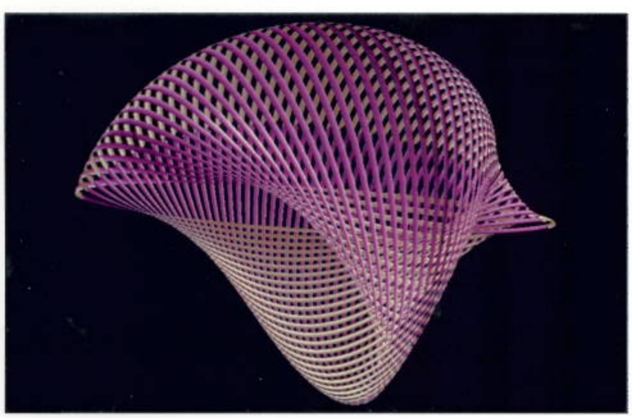
The Art and Interdisciplinary Programs of SIGGRAPH 94

COMPUTER GRAPHICS
Annual Conference Series, 1994

SIGGRAPH 94

A Publication of ACM SIGGRAPH





INTRODUCTION

Attendees experience the actual use and future direction of scientific visualization in computational science and engineering, with emphasis on interactive and collaborative problem solving, in VROOM, the Virtual Reality Room. Virtual environments not only enable scientists to view massive datasets, they also enable them to enter into and interact with the data. Scientists can become smaller than an atom or larger than the universe. They can stand in the middle of a thunderstorm or travel through the human bloodstream. At SIGGRAPH 94, attendees share this full-data immersion experience with the actual scientists, as the scientists conduct a guided tour and explain which areas are of interest to the high-performance computing and communications (HPCC) community.

Over 40 projects involving over 200 researchers and programmers are demonstrated for four days at SIGGRAPH 94. Using CAVE and BOOM virtual reality technologies, researchers show immersive visualizations of their work and demonstrate interactive steering of their program codes using local high-speed networking, massive datastores, superworkstations, supercomputers, and scientific instrumentation. VROOM highlights computational science and engineering applications and computer graphics research. It also has a kid-centered application component called CitySpace.

VROOM's primary goal is to encourage the development of teams, tools, hardware, system software, and human interface models on an accelerated schedule. New interaction paradigms for virtual environments tuned to science and engineering will emerge, which will be the basis for future intelligent user interfaces for the emerging national information infrastructure.

Attendees gain a vision of the 1990's scientific "cyberworkspace." Virtual reality experiences enable researchers to interactively explore their scientific domains, play "what-if" games by modifying their codes, and view the resulting visualizations in close-to-real time. Virtual reality is recognized as an "intelligent user interface" to the emerging national information infrastructure. It will allow computational scientists and engineers access to HPCC-enabling technologies, and it will put the "human in the loop" for timely data analysis and understanding.

Three CAVEs

VROOM features three CAVEs in one place! A CAVE is a multi-person, room-sized, high-resolution, 3D video and audio environment. At SIGGRAPH 94, it is a theater 10 feet by 10 feet by 9 feet with three rear-projection screens for walls and a down-projection screen for the floor. Electrohome Marquis 8000 projectors throw full-color workstation fields (1280x512 stereo) onto the screens at 120 Hz, generating a surrounding composite image of 2,000-4,000 linear pixel resolution. Computer-controlled audio provides sampled sound and sonification capabilities through multiple speakers.

A user's head and hand are tracked with Polhemus or Ascension tethered electromagnetic sensors. Stereographics' LCD stereo shutter glasses are used to separate the alternate fields going to the eyes. A Silicon Graphics Onyx with three Reality Engines is used to create the imagery projected onto three of the four walls. The CAVE's theater area sits in a light-tight room (minimally 30x20x13 feet), and the projectors' optics are folded by mirrors.

As the viewer wearing the location sensor moves within the CAVE's display boundaries, correct perspective and stereo projections of the environment are updated, and the image moves with and surrounds the viewer. Other viewers in the CAVE are like passengers in a bus, along for the ride!

"CAVE," the name selected for this virtual reality theater, is both a recursive acronym (Cave Automatic Virtual Environment) and a reference to "The Simile of the Cave" found in Plato's "Republic," in which the philosopher explored the ideas of perception, reality, and illusion. Plato used the analogy of a person facing the back of a cave filled with shadows, where the shadows are the only basis for understanding what real objects are.

The CAVE, developed by the Electronic Visualization Laboratory at the University of Illinois at Chicago, premiered at SIGGRAPH 92. It is achieving national recognition as an excellent virtual reality prototype and a compelling display environment for computational science and engineering data.

CAVE Interactive Steering of Computer Simulations

Applications can run in one or two modes: locally on the Onyx/CAVE and/or distributed between a backend computer and the Onyx/CAVE. In local mode, CAVE participants explore precomputed datasets. In distributed computing mode, CAVE participants may "interactively steer" their simulation codes running on an onsite IBM SP or on SGI Challenge multi-processor computers.

This ability enables CAVE users to experience and explore visualizations of precomputed datasets, identify an area they want to enhance, and then invoke simulation codes on the networked computer to compute new datasets. The Challenge or SP generates new data, which is then transferred to the Onyx for rendering and display in the CAVE.

Scientific simulation codes are typically large and complex. They require HPCC resources – massively parallel processors, vector processors, massive datastores, large memories, or high-speed networks – to run efficiently. Depending on the dataset and type of analysis scientists select, they set up their simulation codes to calculate greater detail, a different time step, or a different state defined by new parameters. In some instances, codes can be executed locally but take longer to run, so the Challenge and SP are used to provide faster simulation.

BOOM ROOM

The VROOM BOOM ROOM contains a collection of BOOM (Binocular Omni-Oriented Monitors) virtual reality technologies. The BOOM uses small TV screens and wide-field optics suspended by a counterbalanced mechanical arm in front of a viewer's eyes. Fakespace, Inc. developed these light-weight BOOMs to provide accurate lag-free tracking. They are driven by Silicon Graphics workstations to create virtual scenes in real time.

NCSA Mosaic

Hypermedia is an excellent mechanism for the dissemination of visualization-based discovery. Workstations displaying NCSA Mosaic-based documentation of virtual reality visualizations taking place in the CAVEs and BOOMs are located in open areas of VROOM so attendees can learn more about the science and engineering applications on display. After the conference, these documents, complete with text, images, sounds, and animations, are available over the Internet, under the Electronic Visualization Laboratory home page.

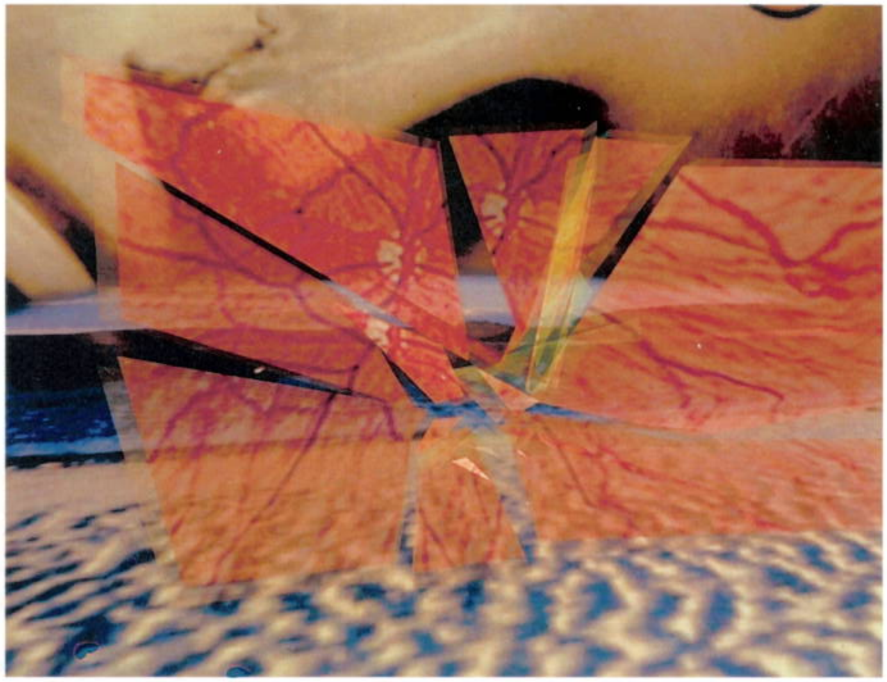
NCSA Mosaic is a hypermedia-based system for discovering and retrieving information over the network. It uses existing Internet protocols and formats to tie into as broad a range of information as possible. It also provides capabilities for asynchronous collaboration based on this distributed model of information access and control, including support for document construction, modification, and annotation.

VROOM Applications

VROOM projects represent a variety of computational science and engineering applications:

Algorithms
Artificial life
Astrophysics
Atmospheric science
Biochemistry
Biomedicine
Collaborative networked visualization
Earth science
Engineering
Fluid mechanics
Fusion physics/energy research
Geometric modeling
Mathematics
Medical imaging
Molecular biology
Neuroscience
Oceanography
Performance analysis
Situational training

DETOUR: Brain Deconstruction Ahead



This autobiographical account by artist Rita Addison describes perceptual changes she experienced subsequent to her head injury in a car accident. DETOUR uses computer brain models and medical imaging to demonstrate anatomical trauma. In the final section, Addison's pre-accident photographic art is reconfigured to simulate the perceptual damage she sustained.

This virtual-reality experience is a powerful way to evoke and stretch empathic capabilities. Whether it is used in collaborative medical evaluations or to educate medical professionals, students, patients, and families, virtual-reality technology is a unique and invaluable tool for communication.

CATEGORY
Medical Imaging

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EQUIPMENT
CAVE

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Interactive Molecular Modeling Using Real-Time Molecular Dynamics Simulations and Virtual Reality Computer Graphics

Using real-time interactive molecular modeling and molecular dynamics simulations, this project demonstrates the docking of a drug molecule to its molecular receptor. A molecular modeler guides a drug molecule into the active site of a protein, receiving real-time feedback from a molecular dynamics simulation running on an IBM SP-1 parallel computer. The molecular system is displayed and manipulated in the CAVE virtual-reality environment.

Using virtual reality, drug designers can interact visually, aurally, and (ultimately) tactilely with molecular models. This environment is enhanced via feedback and input into a simulation that represents the realistic atomic interaction between molecules. Accurate and efficient methods of investigating the recognition and binding of drugs to their biomolecular targets will significantly enhance the drug discovery process.

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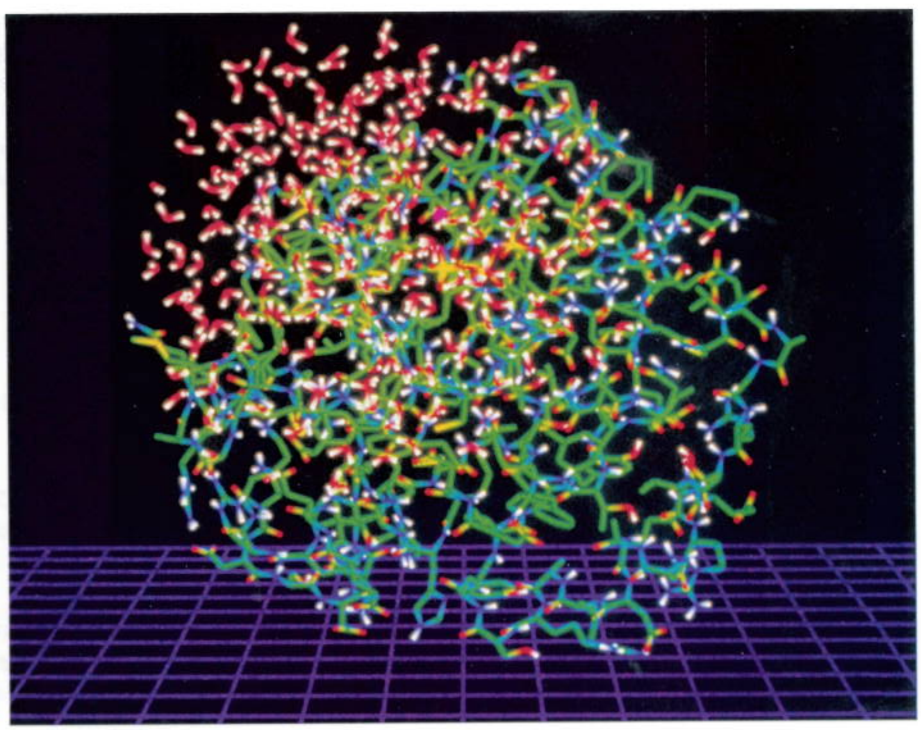

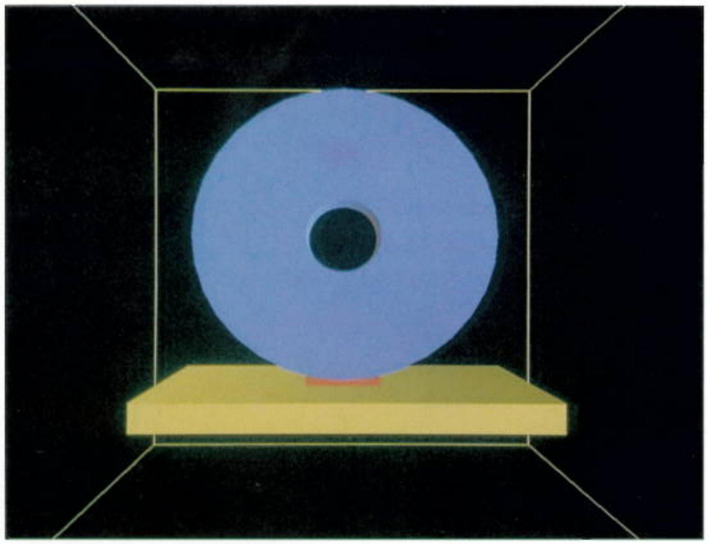

Simulation of a Grinding Process in Virtual Reality

Simulation of a grinding process in the CAVE enables users to explore a commonly used manufacturing process from an entirely new vantage point. An operator performs the simple task of grinding a component by controlling the motion of three axes of the table with the wand. When the wheel is in contact with a part on the table, heat is generated and material is ground away. This produces internal stress and heat flow in the part, wheel, and table. The temperature and stresses are computed in real time on an IBM SP-1 and selectively displayed on the various components as the simulation unfolds. Sound is generated by monitoring the surface motions predicted by the model. Materials ablated by the grinding are ejected as small particles and displayed as sparks.

Analysis of this simple manufacturing process involves solving complex equations at speeds that exceed the perceived event. Real-time interaction between an operator and a "virtual" machine provides new insight into how to interact with the real machine. It also enhances our ability to model physical processes and generate more realistic simulations.

CATEGORY
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Interactive Adaptive Mesh Refinement

Adaptive mesh refinement/derefinement techniques have been shown to be very successful in reducing the computational and storage requirements for solving many partial differential equations. This project focuses on the Rivara bisection technique, which is suitable for use on unstructured triangular meshes such as those used in finite-element calculations.

Virtual reality demonstrates the realization of interactive adaptive mesh refinement. A user indicates the areas of the mesh to be refined using a 3D wand in the virtual space. This interaction is especially desirable in three dimensions, where users are immersed inside the mesh to locate interior regions that require refinement.

CATEGORY
Algorithms

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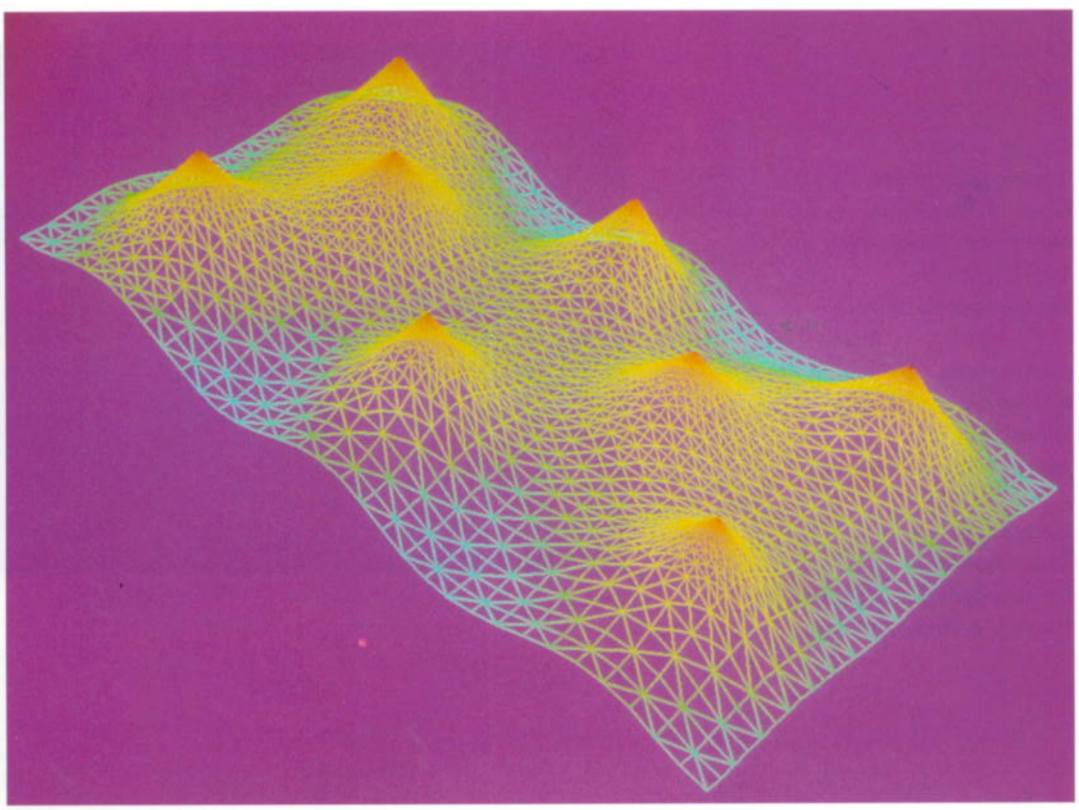

Visualization of Casting Process in Foundries

This application models the pouring of a fluidity spiral used to measure the distance metal can flow in a channel before being stopped by solidification. The gray iron at 1395 degrees C is poured into the mold for two seconds and flows down the spiral arm turning to mush at 1215 degrees C and solidifying at 1150 degrees C. The casting then continues to lose heat to the mold until solidification is complete.

The calculations were performed using the Casting Process Simulator (CaPS), robust multidimensional time-dependent computer code that uses a finite-volume formulation in solving mass, momentum, and energy equations, and performs mold filling and solidification.

CATEGORY
Engineering

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ACKNOWLEDGEMENTS
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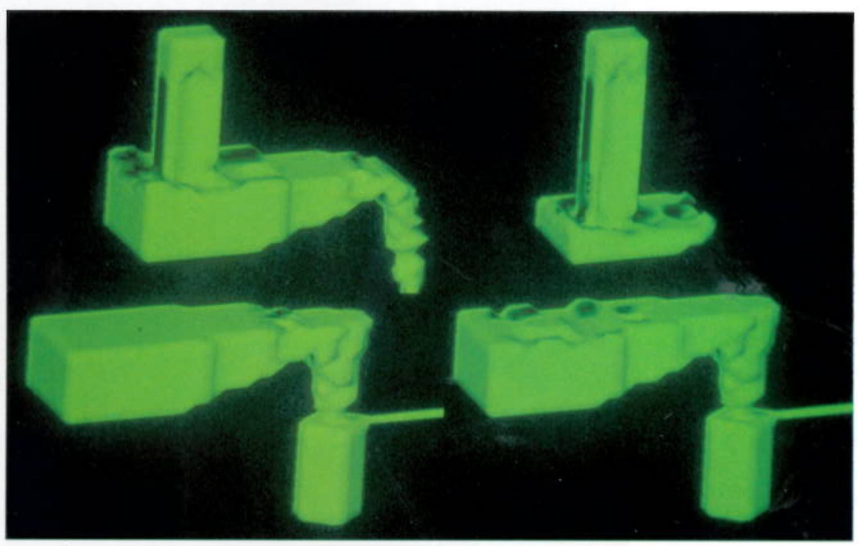

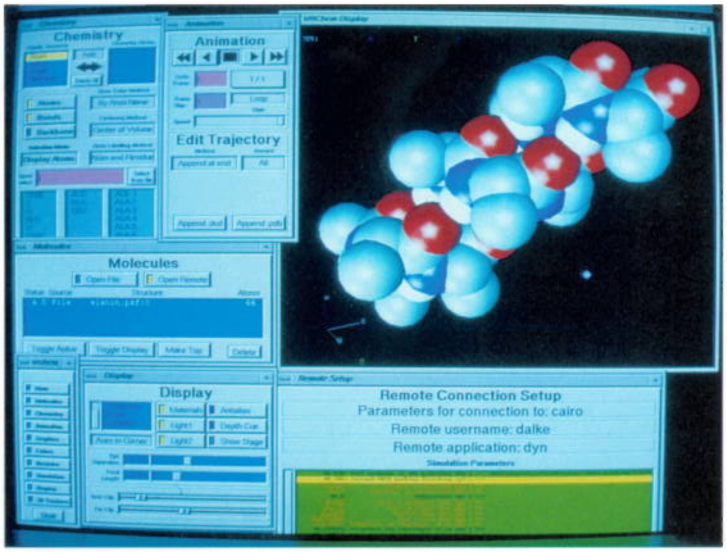

Distributed Interactive Molecular Dynamics

Starting with the experimentally determined atomic structure of a molecule, the force on each atom is computed, and then the motion of the whole molecule. These molecular dynamics simulations are used to explain reactions that are hard to investigate by other means.

As the power of computers has grown, the size of these simulations has increased, and the amount of information generated and required by them has become overwhelming. For example, a typical simulation may produce 500 megabytes of output. In order to make sense of this large amount of data, this project uses the extra information available in a 3D virtual presentation.

CATEGORY
Molecular Biology

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RealEyes: A System for Visualizing Very Large Physical Structures

Both airplanes and space stations are extraordinarily complex systems. They each contain millions of parts. Determining how well large assemblies of parts will fit together (or how they won't) while they are still at the design stage is a very important task, because fixing these sorts of design problems after the parts are manufactured is far more difficult and expensive than fixing the problems at the design stage.

Boeing demonstrates some very large, complex CAD models of a Boeing 747 interior and Space Station Freedom. These models are taken directly from the design engineers, and each contains several million polygons (several orders of magnitude more than models displayed in other systems). They are quite detailed, right down to the airflow controls above each seat and the hot/cold labels on the water faucets.

This virtual reality system allows engineers to discover and analyze problems using much larger collections of CAD models than ever before. The navigation interface is easily learned by novices, and it is much more powerful in the hands of expert users than any screen-based interface known to the Boeing engineers who designed it.

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Engineering

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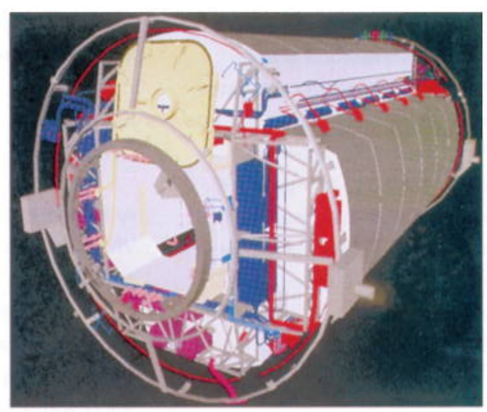

Phase and Amplitude Maps of the Electric Organ Discharge of the Weakly Electric Fish, Apteronotus Leptorhynchus (Brown Ghost)

This demonstration models the Apteronotus Leptorhynchus (commonly known as the Brown Ghost). It displays simulated data of the electric fields emitted by the fish, as well as how the fields are distorted by an object placed in the surrounding water.

The purpose of this fish simulation is to establish an understanding of how emissions are generated by the real fish. Since humans do not have an electric sense, it is difficult to comprehend how fish electric fields "feel". Alternative techniques, such as virtual reality, must be used to acquire some of that sensation. The results will help us understand how this fish uses phase and amplitude information from the electric organ discharge for electrolocation and communication.

CATEGORY
Neuroscience

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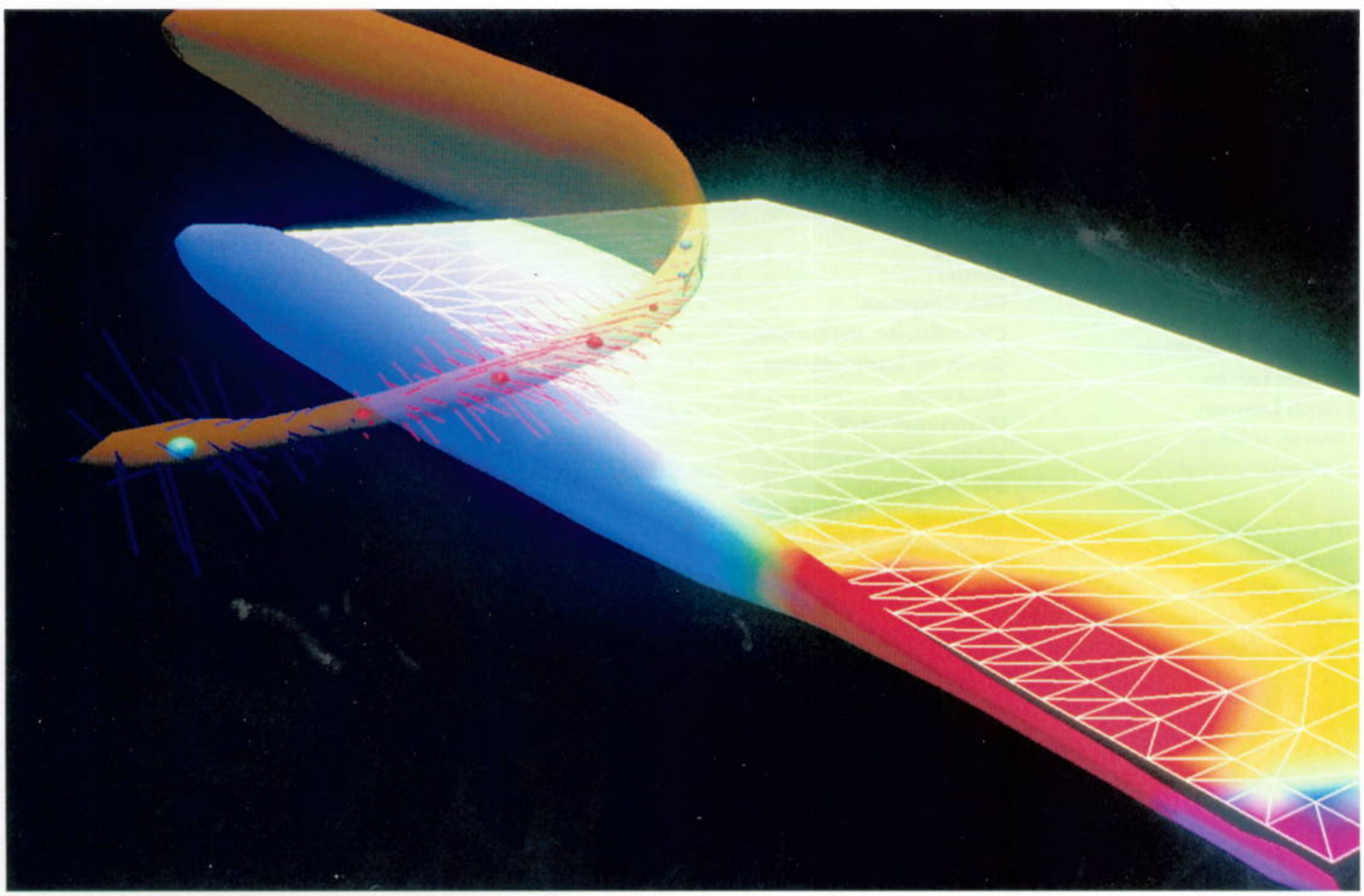
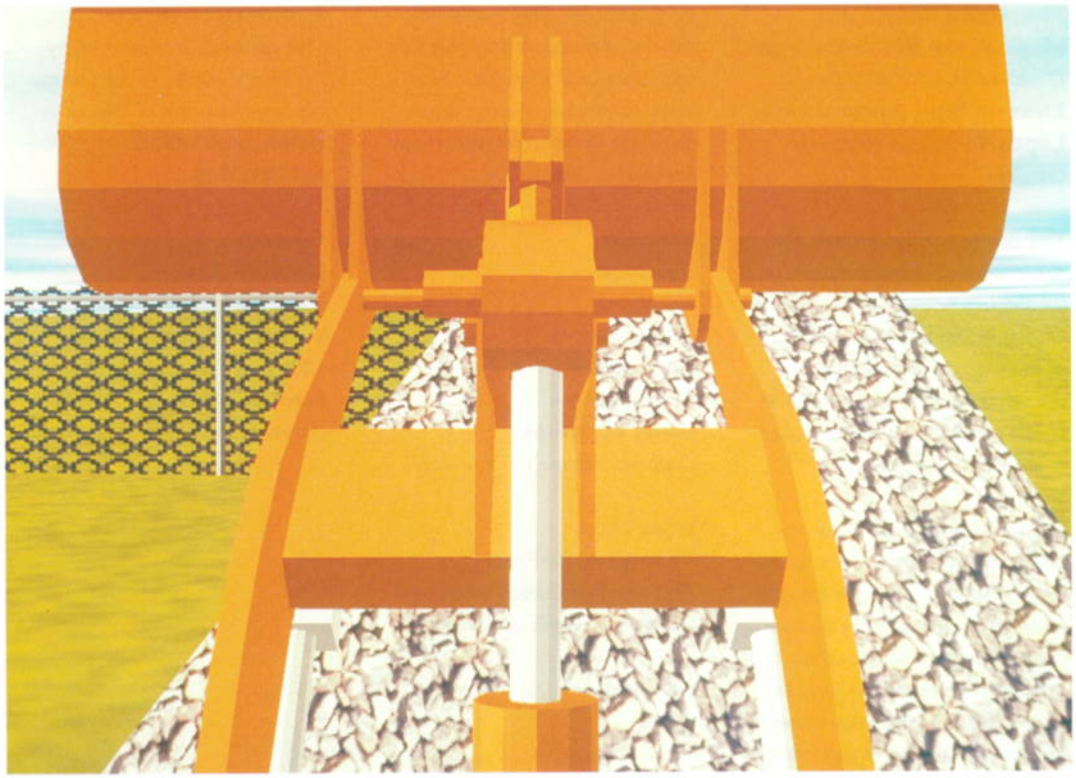


Using Virtual Reality for Machine Design



Caterpillar, Inc. uses virtual reality as a tool for interactively evaluating new machine designs. Using virtual reality, the operator of a virtual machine can test alternative machine designs while driving through a virtual proving ground, or can perform a loading cycle to fill a truck with soil. Hydraulically-actuated tools can be assessed with various hydraulic systems.

Using a virtual reality system enables engineers and designers to get a "feel" for their machine designs very early in the design stage. They can evaluate many different designs in less time than conventional methods require.

CATEGORY
Engineering

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Acetylcholinesterase: Nature's Vacuum Cleaner

This research focuses on the electrostatic forces generated by Acetylcholinesterase, an enzyme that plays a key role in the human nervous system. Neurotransmitter molecules (acetylcholine) are drawn down a long tunnel and into a "reactive-site" cavern deep within the enzyme where they are cleaved into component parts for reuse. By literally voyaging into the enzyme along a route similar to that taken by neurotransmitter molecules, researchers gain a unique vantage point from which to examine the electrostatic field and other computed probes of enzyme activity. An immersive display also is a unique medium for helping non-specialists understand a sequence of chemical events that would otherwise be difficult to convey.

Improved understanding of the actual forces and dynamics at work in the acetylcholinesterase process should enable design of novel inhibitor molecules that have therapeutic value.

CATEGORY
Biochemistry

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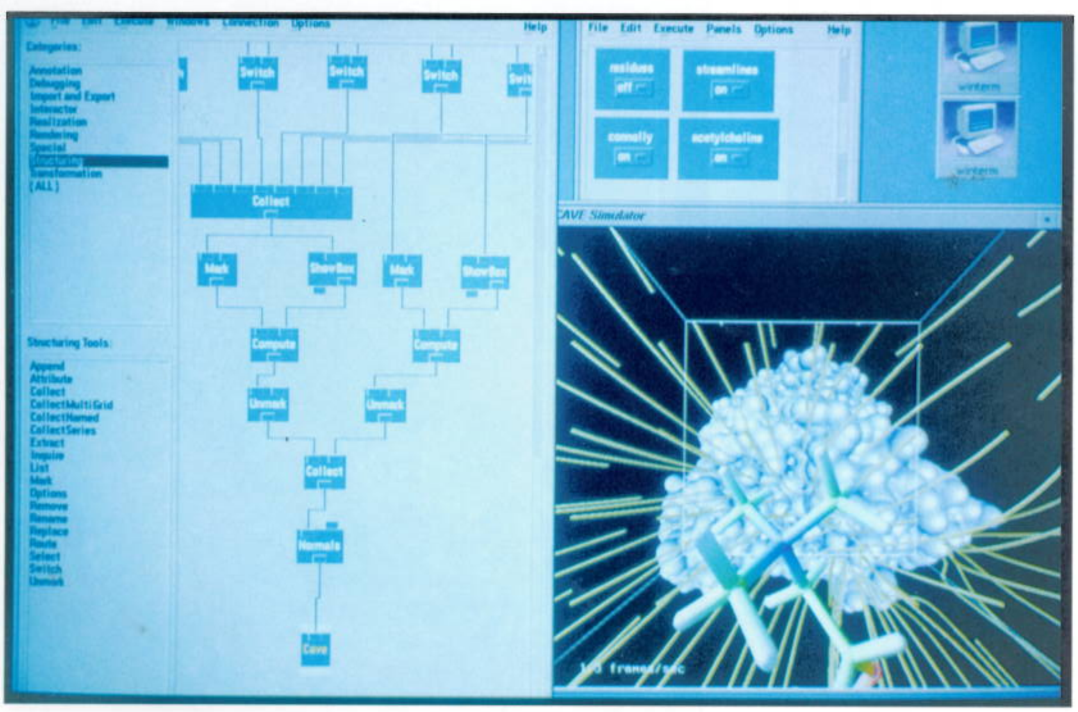

Visualization of Climate Data Over the Western United States

Many climatologists are interested in understanding energy transport in the atmosphere due to wind and precipitation. To achieve this goal, they must be able to observe anomalies and patterns, and they must be able to visualize cause-and-effect relationships implied by earth science data. Since these data either measure or simulate actual physical phenomena that humans sense in everyday life, it is natural to visualize this information in a way that emulates or complements our experience. A thesis currently being investigated is that immersion in a virtual world that models the one we live in may enable scientists to better understand the Earth's dynamic climatic processes.

This demonstration represents output from a regional climate model for the western United States. Data from the model are compared with actual measurements to help gauge the validity of the model.

CATEGORY
Earth Science

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CAVE

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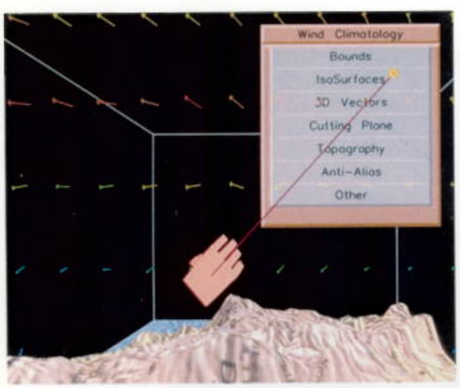

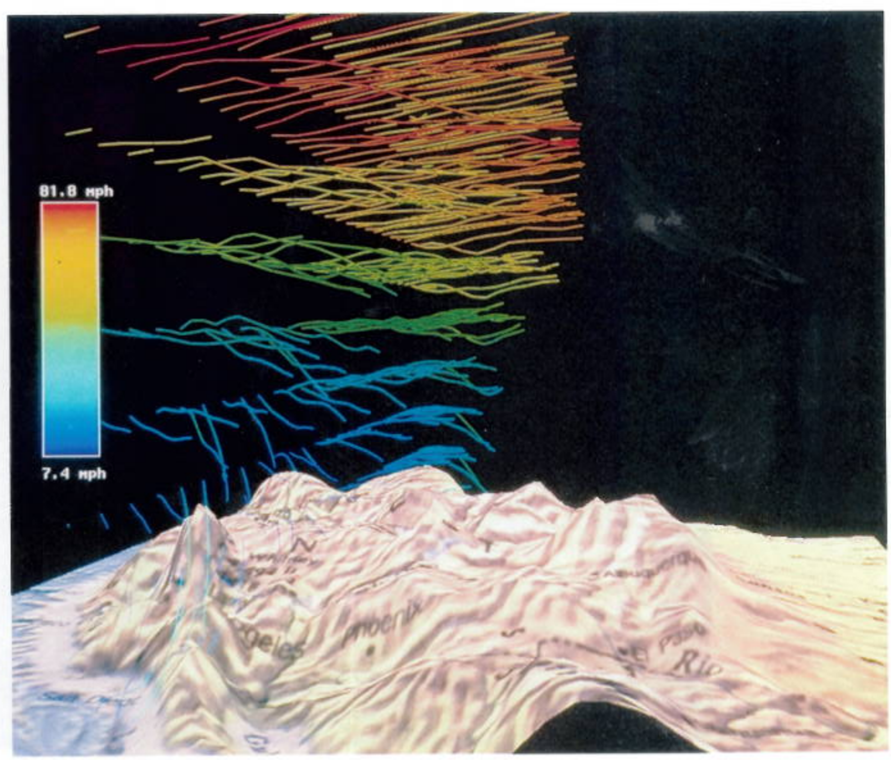

Simulation of Light and Sound Distribution in an Environment

One application of virtual reality is imitation of the real world. Using virtual reality, the optic and acoustic behaviors of an environment can be experienced directly, and modifications can be evaluated immediately. In this demonstration, light and sound distribution in different room types is simulated. Simulation parameters and room properties can be modified interactively, and the resulting optic and acoustic energy distributions can be visualized.

CATEGORY
Algorithms (lighting, acoustics)

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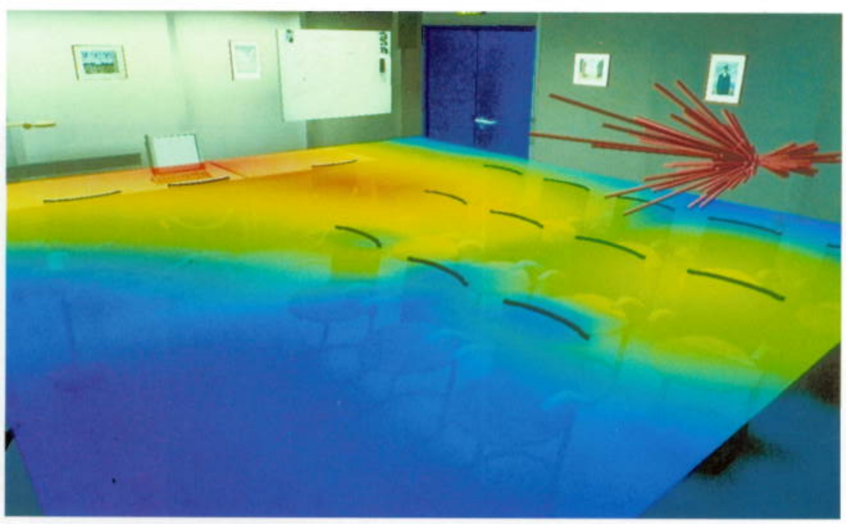

Knotted Spheres in the Fourth Dimension

Computer graphics simulations of virtual worlds help us develop intuition about objects we can never experience in real life. This demonstration exactly simulates interaction with images of complicated 4D structures as they would be experienced by an individual actually living in the fourth dimension and seeing with 4D light. The distinguishing feature of this virtual 4D world is that it produces holistic images that reveal global, rather than local, properties of the objects depicted.

Knotted Spheres in the Fourth Dimension exhibits real-time interaction with knotted spheres (knotted two-manifolds embedded in 4D space). A typical approach to visualizing such a surface is to project it into 3D and view it with 3D lighting, but this omits nearly all of the interesting 4D information about the structure. Instead, this system uses a fast approximation to volume-rendering volume images of projected 4D objects with true 4D lighting and occlusion, enabling viewers to interact with and pick out important mathematical features of this class of objects.

CATEGORY
Mathematics

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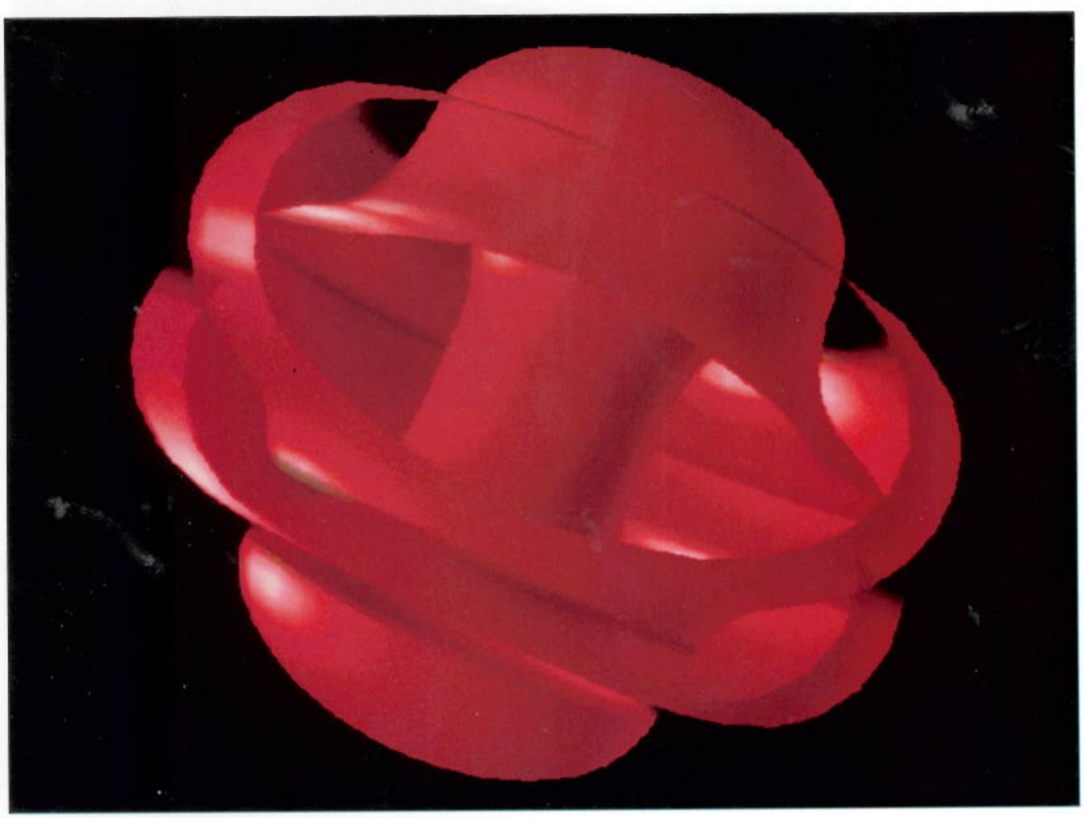

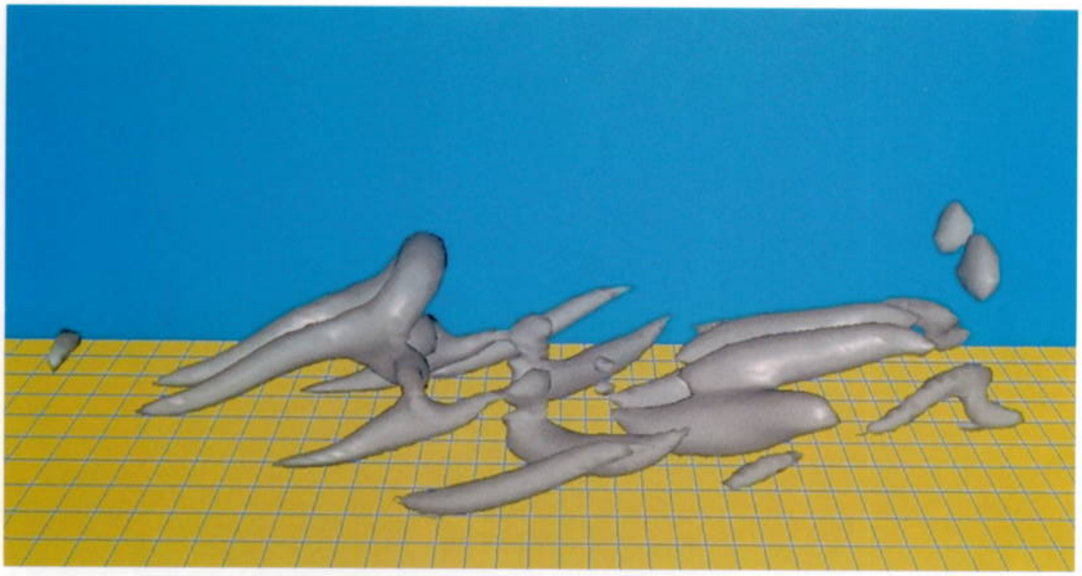

The Onset of Turbulence in a Shear Flow Over a Flat Plate

Smooth, laminar flow over a flat plate eventually becomes turbulent. The transition to turbulence generally occurs on a scale that is too small and too fast for an observer to appreciate in an empirical experiment. This application lets the user track the development of a turbulent spot (from a numerical simulation) at a size and speed that are comprehensible.

CATEGORY
Fluid Mechanics

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ACKNOWLEDGEMENTS
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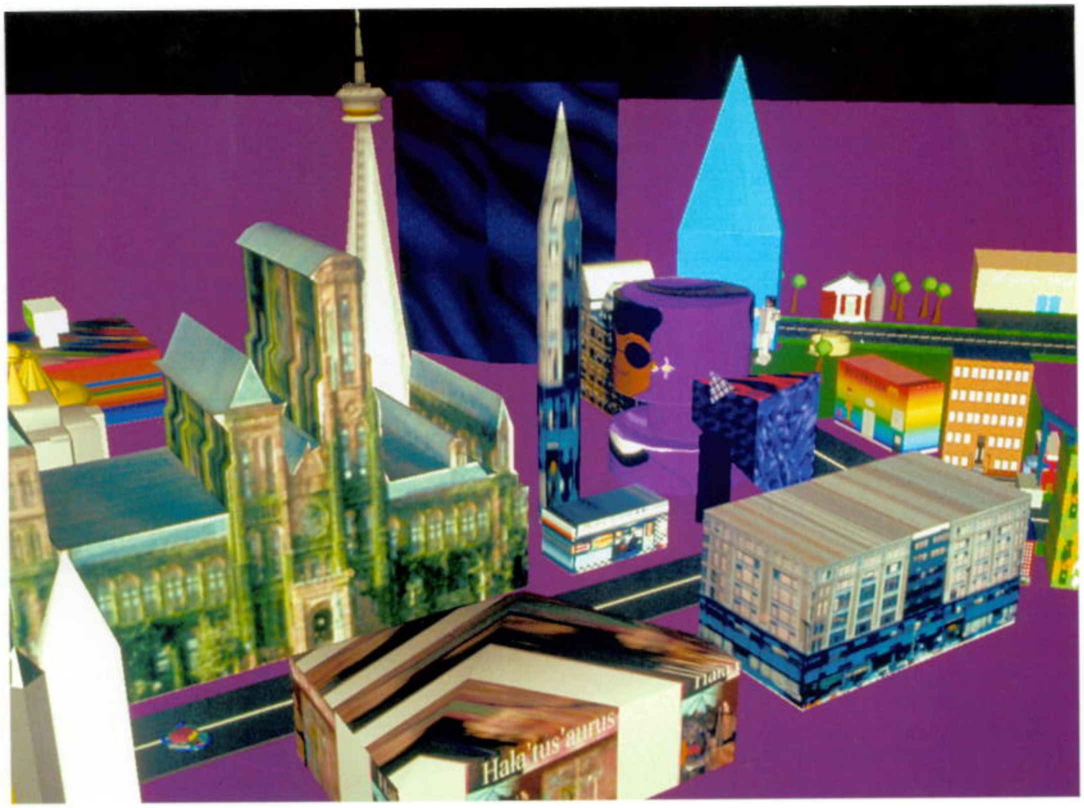
CitySpace



CitySpace is an educational networking project that invites students to build a virtual city model made up of 3D objects and images from sites around the world. The CitySpace project strives to present a learning model based on collaboration, simulation, visualization, and wide-area digital networking. The project is intended for integration into project-based curricula and is designed for self-managing groups of students, mentors, teachers, and resource administrators. The model relies on a flexible, open, high-speed network based on client-server technology, widespread access to desktop digital media production tools, and efficient utilization of high-end computational resources.

Category
Collaborative Networked Visualization

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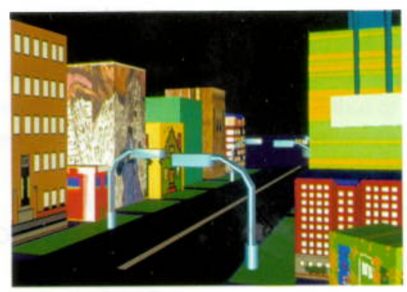

The Virtual Windtunnel

The Virtual Windtunnel is an application of virtual reality to the visualization of pre-computed simulations of air flow around aircraft. Through a natural 3D display and control interface, the Virtual Windtunnel provides a platform for intuitive and rapid investigation of complex airflows.

Category
Engineering

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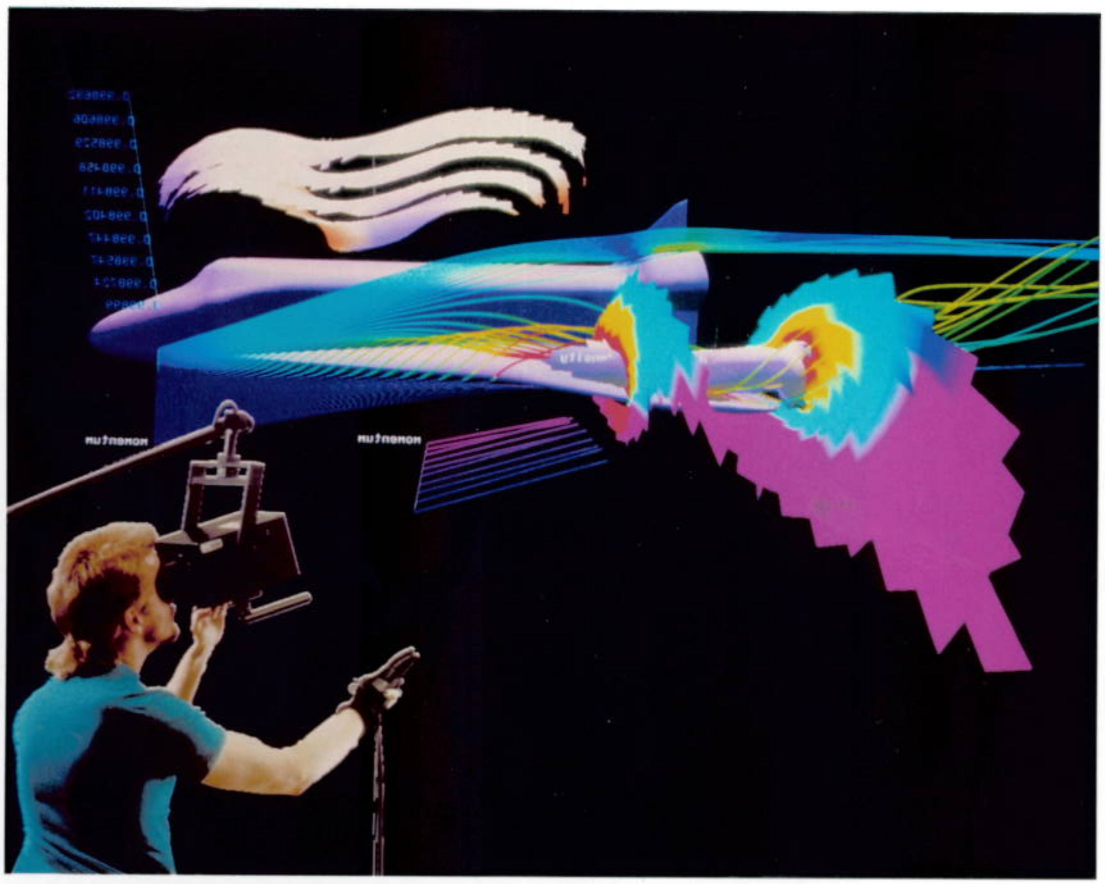

Three-Dimensional Terminal Viewer (3DTV)

Impaired visibility conditions caused by nightfall or precipitation can preclude aviation system users from obtaining the visual cues often helpful in detecting aviation weather hazards. Other aviation weather hazards cannot be detected by the naked eye. 3DTV was developed to study the value of real-time 3D visualization of derived weather hazards, such as microbursts, wind gust fronts, and heavy precipitation regions, to the aviation community. It provides a virtual environment that allows users to have a more intuitive understanding of the aviation weather hazard situation within the terminal area, and to promote effective communication between users through a shared and heightened situational awareness.

Algorithms, fed by real-time sensors such as Doppler weather radars, extract aviation weather hazards and allow the creation of a virtual world derived from physical phenomena. The system uses icons and surfaces to present an unobscured view of weather hazards to the target audience: air traffic managers, flow control specialists, and pilots.

CATEGORY
Atmospheric Science

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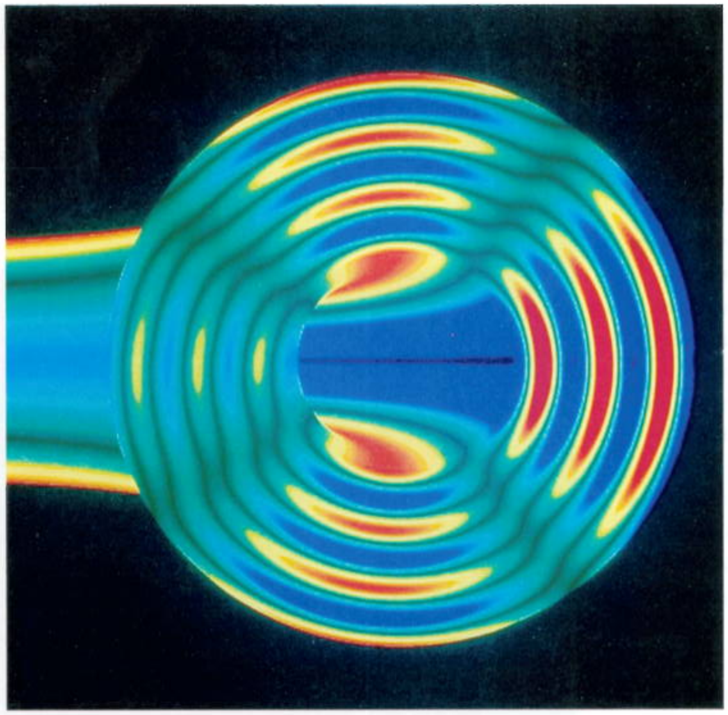
Scientific Visualization of Gyrofluid Tokamak Turbulence Simulation



High-performance algorithms for simulating and visualizing 3D plasma turbulence in magnetic fusion experiments have been developed as an aid in the development of more accurate predictive models of plasma transport and the design of future experiments. This work is part of the Numerical Tokamak Project, a national consortium of efforts using the most powerful supercomputers in the world to develop and use such numerical models. Virtual reality represents a "next step" in the development of a visualization system already in use by collaborators in the Numerical Tokamak Project.

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Fusion Physics/Energy Research

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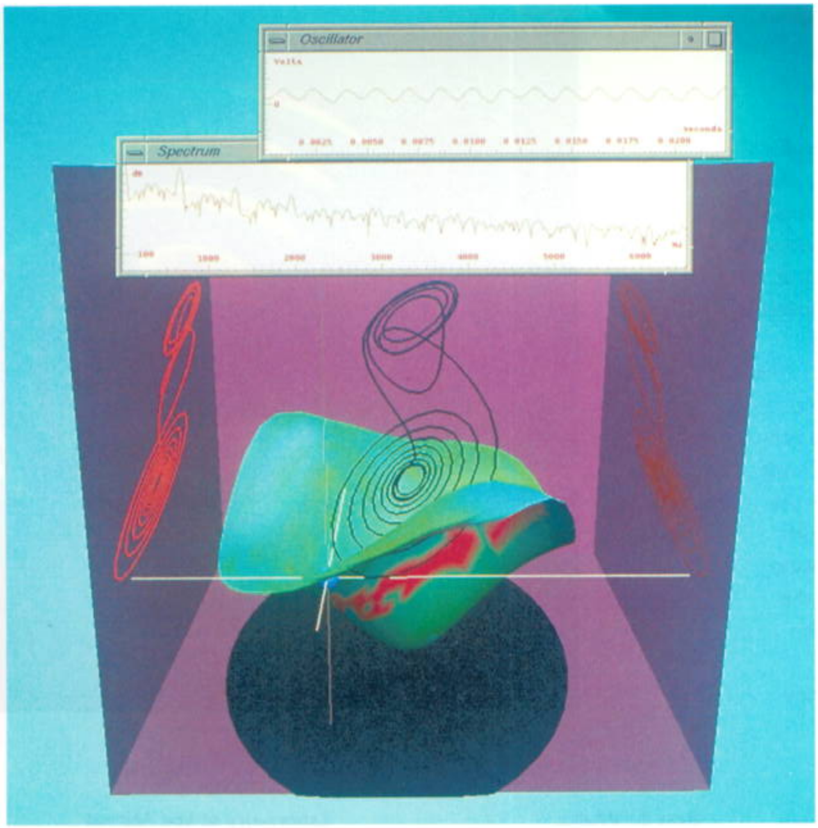
Sounds from Chaos in Chua's Circuit



To exhibit chaotic behavior, an autonomous electronic circuit must contain at least one nonlinear element, one locally active resistor, and three energy storage elements. Chua's circuit is the simplest electronic circuit that contains these elements, and it is the only physical system for which the presence of chaos has been proven mathematically. It has become a paradigm for the study of chaos due to its universal chaotic properties, its simple circuit design, its ease of construction, and its rich variety of over 40 attractors.

Chua's circuit produces many types of signals, from sine-like periodic patterns to unpredictable noise-like patterns. These continuous signals can be generated in the human auditory range and displayed as sound using an amplifier and speakers or headphones. Sometimes, the sound resembles familiar musical tones. Other times, it produces novel sounds that contain both pitched and noise characteristics. By listening to the sound, observers can study fine details of a chaotic attractor. A composer could also organize the sounds into a musical presentation.

The unique aspect of the display of this study in virtual space is the simultaneous presentation of control space (manifold) and output phase space of the circuit. As users navigate the manifold surface, they receive immediate feedback by observing the phase display of the signal as well as changing acoustic responses.

CATEGORY
Algorithms (auditory display); Mathematics

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The Fluid Universe: Rayleigh-Taylor Instability in Fluid Flow

This interactive simulation of Rayleigh-Taylor instability shows what happens when a heavier fluid lies on top of a lighter fluid. The gravitational force causes the heavier liquid to form "fluid fingers" that flow down into the lighter liquid, causing mixing and turbulence. There are many astrophysical objects that show this kind of behavior, such as the remnants of giant explosions called supernova and the atmospheres of some stars.

Scientists viewing this application in the CAVE have achieved a better understanding of the texture (or morphology) of the data produced by the simulations. Specifically, the evolution of small eddies on the sides of the large Rayleigh-Taylor finger were very interesting to observe.

CATEGORY
Astrophysics

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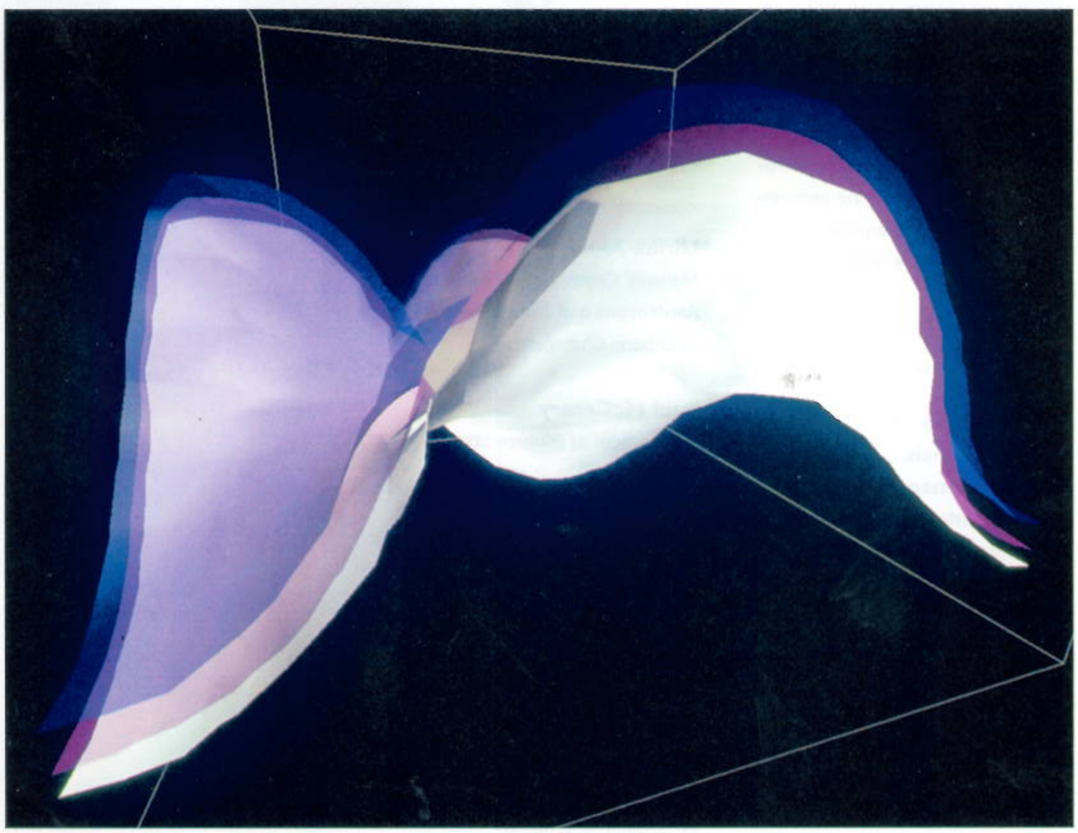

Post-Euclidean Walkabout

This real-time interactive CAVE application takes you on a visit to the post-Euclidean geometry of Gauss, Riemann, Klein, Poincare, and Thurston. Here you can walk into a rectangular dodecahedron, a shape which is possible only in negatively curved hyperbolic space. With a wand, you can summon and play with the snail-shaped 3D shadows of soap films in positively curved elliptic space. You can see how to sew the edges of hyperbolic octagons together into the surface of a 2-holed donut. The CAVE becomes a spaceship you can navigate with the wand, as it glides through the phantasmic shapes that populate the 3-sphere.

The purpose of this project is to perfect persuasive visual and sonic environments in which to exhibit geometrical wonders and their startling metamorphoses, which interest research geometers. Convincing visualizations of multi-dimensional, time-varying geometrical structures are equally useful in applied and pure mathematics.

CATEGORY
Mathematics

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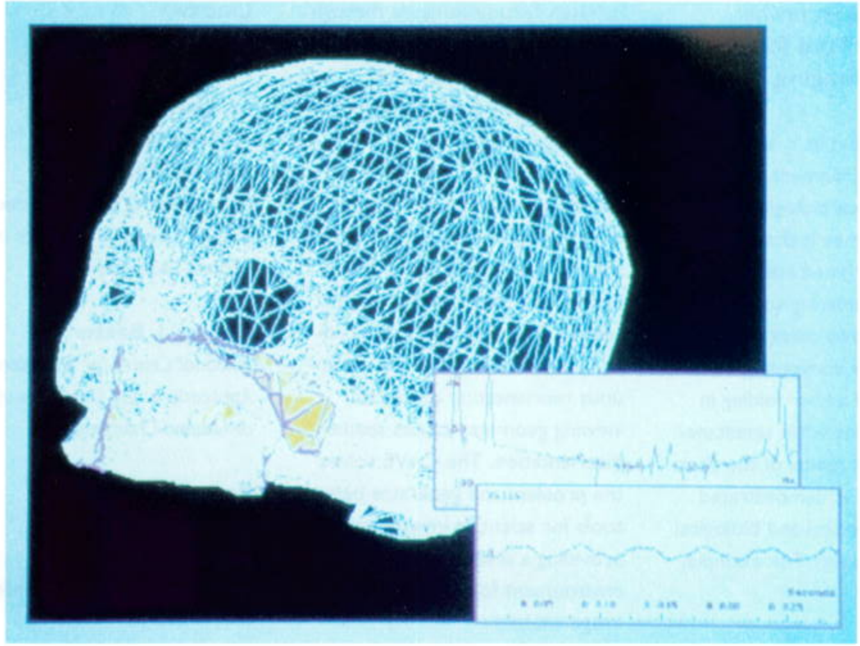
Stepping Into Alpha Shapes



A finite set of points in 3D space and a real-parameter *alpha* uniquely define a simplicial complex, consisting of vertices, edges, triangles, and tetrahedra embedded in space: the *alpha complex* of the points. The *alpha shape* is the geometric object defined as the union of the elements of the complex. By varying the values of alpha, the system can create crude or fine shapes – from convex hulls to detailed structures containing cavities that may join to form tunnels and voids. Several graphical interaction techniques, as well as the use of sound synthesis, enable users to explore alpha complexes with meaningful visual and auditory cues. Alpha shapes have application in geometric modeling, grid generation, protein structure analysis, and medical image analysis.

The alpha-shape software constructs a geometric object with detailed and possibly quite complicated features on the outside and inside. The CAVE enables the immersive visual inspection of features. The audio experience is made possible through real-time sound synthesis that reflects the detailed structure of the alpha shape.

CATEGORY
Geometric Modeling

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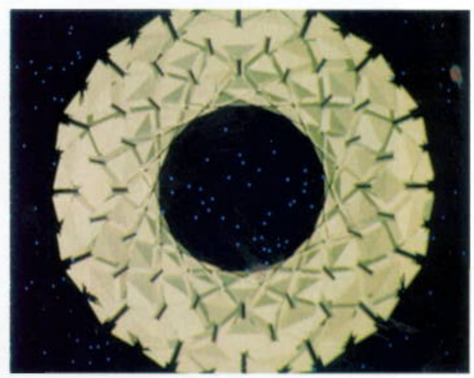

Virtual Breadcrumbs: A Tracking Tool for Biological Imaging

Virtual Breadcrumbs is an immersive virtual environment tool for tracking complex biological structures in a volumetric dataset. Through a combined volume and solid-model rendering visualization interface, it allows users to walk along the highly convoluted and twisted path of a fiber folding in three dimensions while simultaneously building a model of the fiber track. The tool is demonstrated with several medical and biological volumetric datasets. For example, it tracks chromatin fibers through the nucleus, cytoskeleton fibers through the cytoplasm, and neurons within brain slices from microscopic datasets.

The ability to track the structure of biological objects through a 3D volume is an important problem in biological and medical image analysis. It is also a difficult problem, because the need for continuous reorientation of the 3D viewing geometry causes spatial disorientation. The CAVE solves the problem and generates better tools for scientific investigation by providing a unique immersive environment for 3D biological image analysis.

CATEGORY
Medical Imaging

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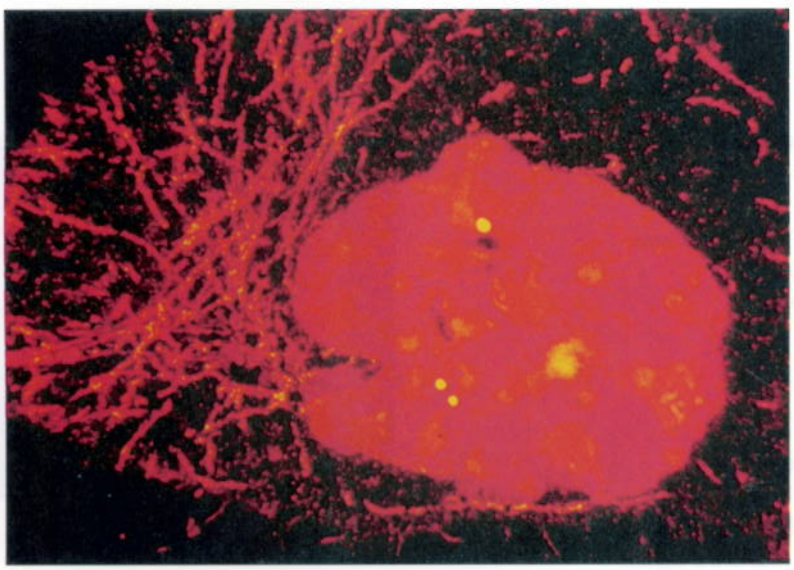
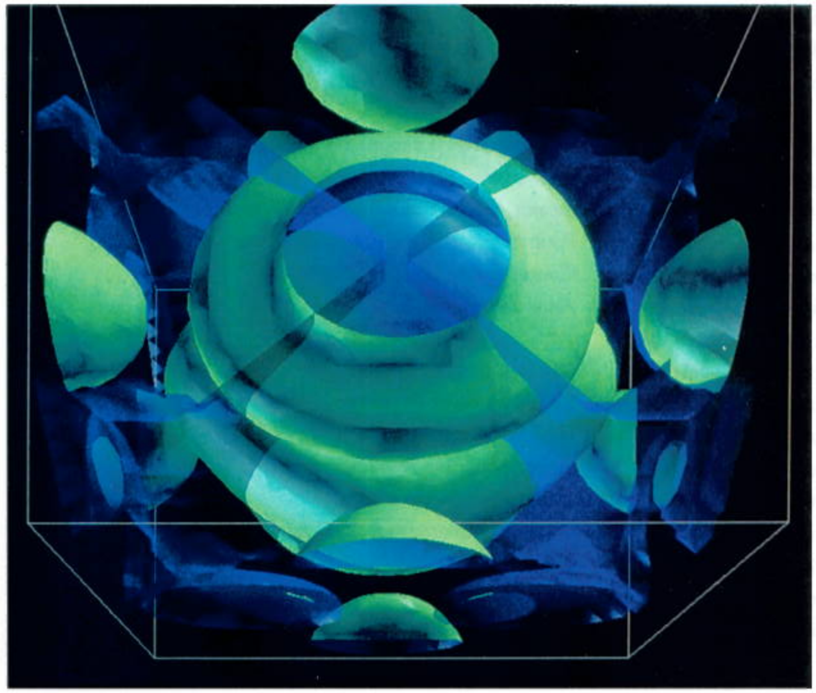


Spacetime Splashes: Catching the Wave of Einstein's Equations



Astrophysicists are interested in applying virtual reality and scientific visualization to spacetime simulations to help them better understand and interpret numerical studies of black holes, gravitational waves, and the Einstein equations for the gravitational field.

Einstein's theory of gravity, known as general relativity, is a complex set of nonlinear partial differential equations. In this project, full 3D codes have been developed to solve these equations for the gravitational field. The demonstration shows gravitational waves propagating through spacetime according to Einstein's equations for the gravitational field. The waves are disturbances in the gravitational field that travel at the speed of light. The simulation computes the evolution of various components of the waves.

CATEGORY
Astrophysics

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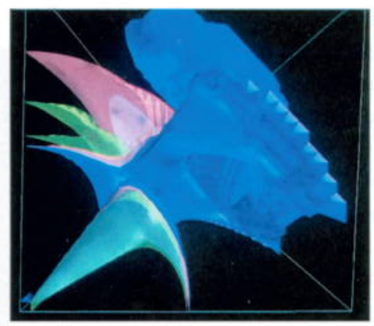

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Molecular Recognition in Protein-Protein Association

The phenomenon of macromolecular recognition is of immense interest in medicine and biotechnology. This process is studied in immune-system proteins in order to precisely delineate the nature of recognition between antibodies and antigens at various levels. In this demonstration, the steered encounter of an antibody is simulated using Brownian dynamics, and the trajectories are visualized in a virtual-reality environment to provide an intimate picture of interactions between the antibody and the protein.

CATEGORY
Biochemistry

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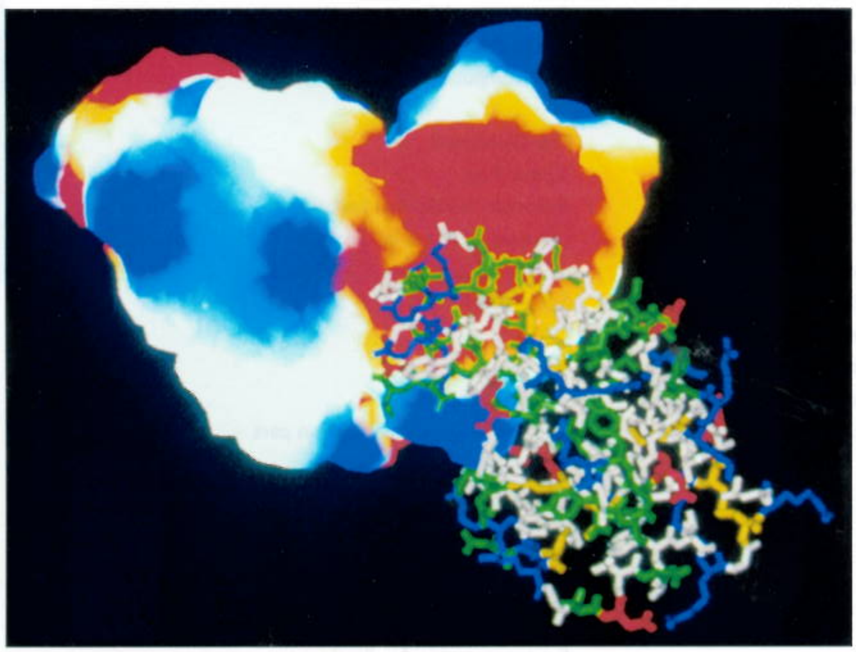

The Development of Tornadoes with Storms and Along Gust Fronts

This demonstration is derived from current investigations of the processes involved in tornado genesis along thunderstorm outflow boundaries. The massively parallel CM-5 and CM-2 supercomputers are being used to numerically simulate the local environments that support these tornadoes. Rendered isosurfaces, such as temperature surfaces, give a tangible representation of the outflow leading-edge structure and key instabilities that may be present. Trajectories launched near these instabilities yield valuable information about the flow regime present at the outflow leading edge.

CATEGORY
Atmospheric Science

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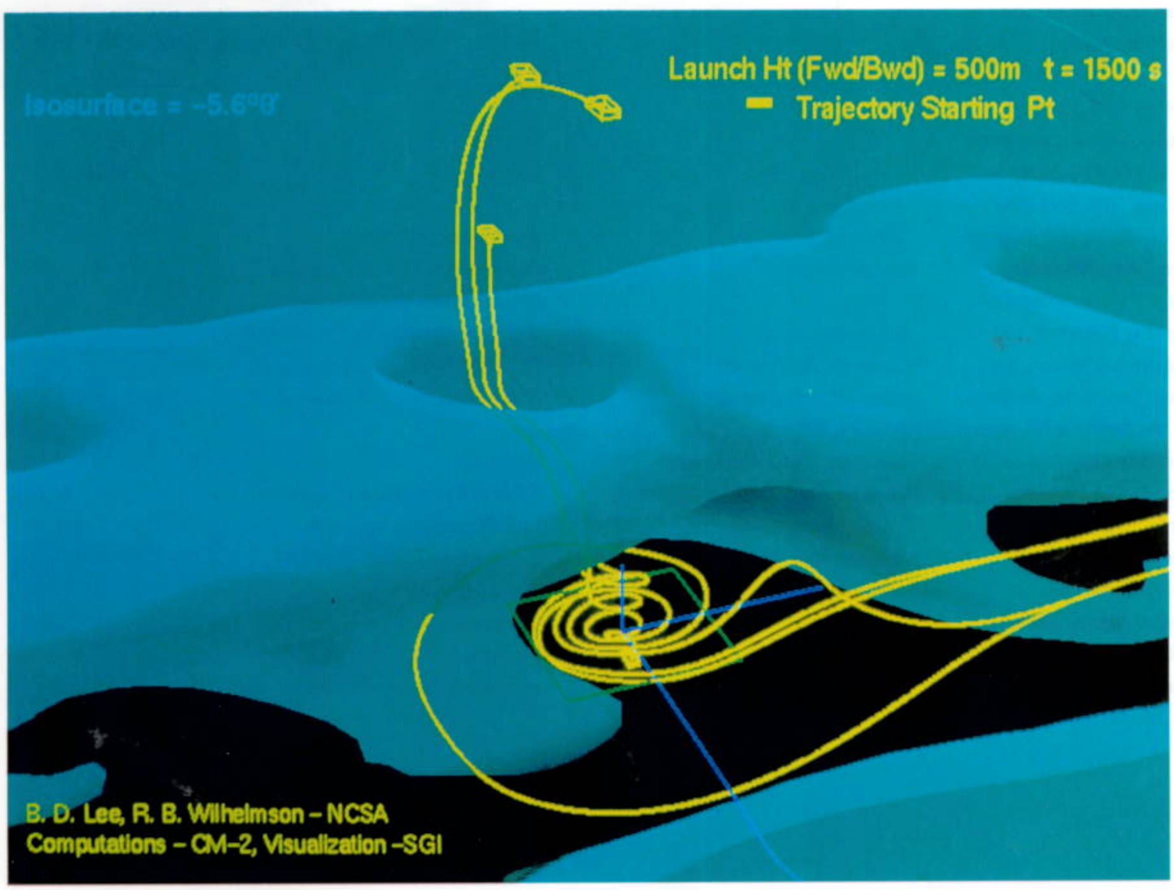

A Walk Through Chesapeake Bay

Unlike the atmosphere, the world's oceans are opaque, and processes that occur beneath the sea surface cannot be directly viewed. What little we see is inferred from measurements made with remote sensing instruments. Though it can be useful, this approach limits the ability of scientists (and the general public) to experience the many and varied processes that occur in marine environments. Now, with recent advances in computing and visualization, individuals can experience the environment beneath the sea surface in a visualization framework that is familiar to them. A visualization approach also allows many processes to be integrated, so that interaction of complex oceanic systems can be demonstrated (e.g., circulation and ecosystem dynamics).

Freshwater input is a primary forcing function for the circulation of estuarine systems such as the Chesapeake Bay. This first effort to focus on visualizing the input of freshwater to Chesapeake Bay allows the study of the effects of the Susquehanna, Potomac, and James Rivers, among others, on the salinity and hence the density structure of the Bay in a 3D time-dependent framework. This study combines bottom bathymetry, river discharge, hydrographic (temperature and salinity) datasets, and tidal datasets for the Chesapeake Bay, as well as circulation distributions from a numerical circulation model constructed for the Bay.

CATEGORY
Oceanography

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3D Hydrodynamic Model of the Heart

This computational model of the heart treats the heart wall as a set of fibers immersed in fluid and responding to both fluid forces and tension forces. The fluid, in turn, experiences a force field in the neighborhood of the fibers that prevents flow through the gaps in the fiber network, allowing the heart to pump the fluid. The anatomy modeled is that of a hog heart, for comparison with experimental data.

The main goal of this virtual-reality project is investigational. The hope is that it will help clarify the relevance of virtual reality to this type of study.

CATEGORY
Biomedicine

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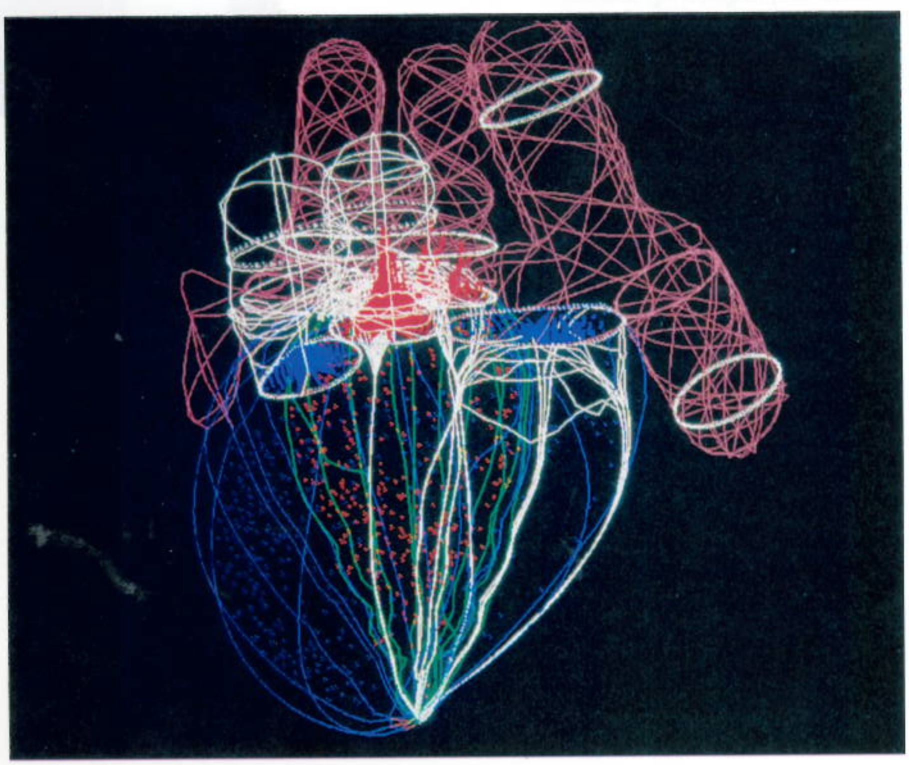
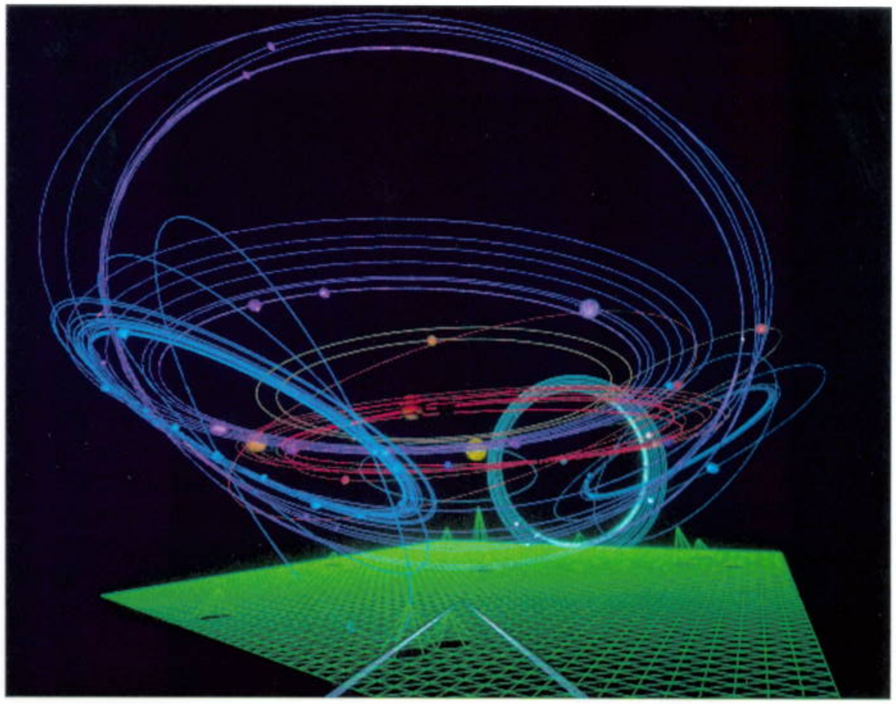
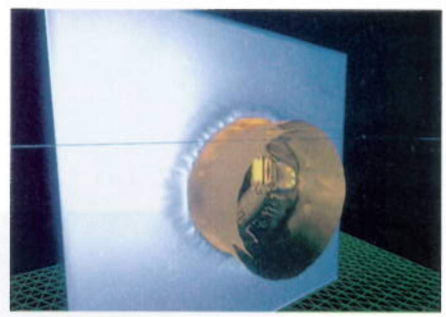


MUSE: Multi-Dimensional, User-Oriented, Synthetic Environment



MUSE is an open-software environment that provides a new approach to the human-computer interface. Using functional models of human interaction and physical device classes, it permits real-time mapping of user control onto application/system functions (input), and mapping of computer information onto different types of output devices. It is device-independent and handles different types of displays (from flat-screen to head-tracked stereo displays), voice recognition, speech synthesis, sound generation, and a variety of analog input devices. It supports simultaneously shared, networked environments and provides a versatile craft model with control, navigation, manipulation, and display capability to facilitate exploration and analysis of complex information spaces.

VROOM showcases a number of scientific and engineering applications that use MUSE, including: volumetric CT scan data; a modular analog controller (fusing approximately 36 different types of time-dependent information, from finite-element thermal analysis to electrical circuit simulation, into visual, auditory and craft displays); explosive welding (using an explosive charge to instantly weld a copper pipe to a beveled steel plate and to deform the pipe to match the bevel); and a simulation of the solar system in logarithmic scale that covers a spatial range of 10^{10} kilometers, with a dynamic positioning resolution of approximately 25 kilometers.



CATEGORY
Algorithms (human/computer interface); Engineering; Scientific

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Real-Time Graphics Techniques Using IRIS Performer

Whether used as a training simulator or as an architectural design tool, most visual simulations try to achieve a sense of immersion for better usability and enhanced training value.

These virtual environments demonstrate various techniques in real-time computer graphics using IRIS Performer, a performance-oriented, multiprocessing 3D graphics toolkit. The techniques include level-of-detail control for frame-rate constancy, view culling, texture mapping, detail texturing, pre-computed animation sequences, billboard polygons, and morphing. The scenarios include a drive through a town, a walk through a radiosity-solved architectural model, and a demonstration of real-time shadow generation using projected texturing.

CATEGORY
Algorithms

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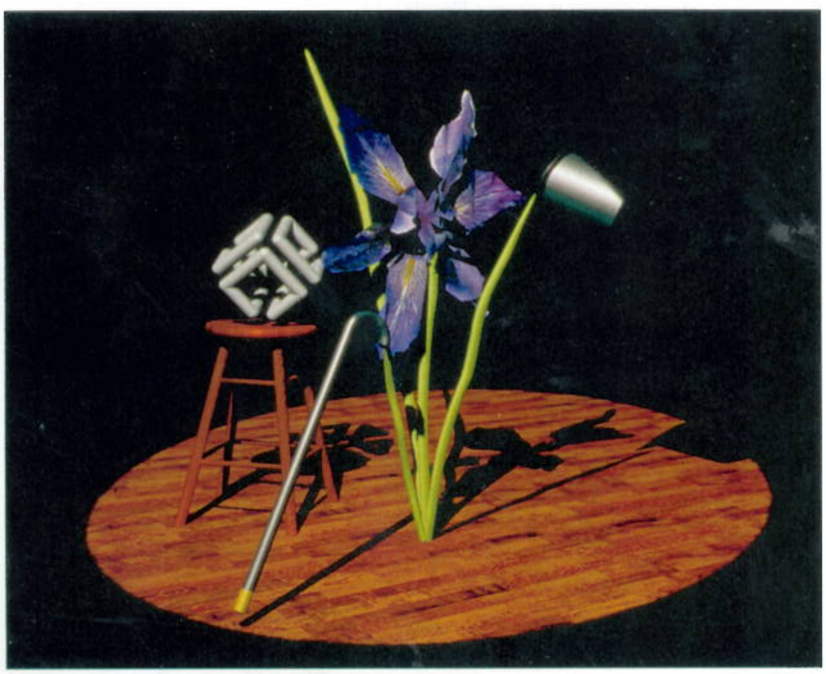

Virtual Exploration of a Florida Thunderstorm Using the SciAn Visualization Package

Raw and analyzed data from a variety of sources, as well as simulation, are used to explore a storm system in central Florida. The purpose of this research is to better understand the relationships among the co-evolving wind, water, and electric fields, with the goal of improving numeric models of storm systems and improving forecasts of precipitation, lightning, tornadoes, and downbursts.

Exploring the data in a virtual environment gives a better overall understanding of the structure of the storm than is possible with static or animated images on a flat screen. The ability to interact with the data in an inherently 3D space allows more natural exploration of the properties of the data. Merging an immersive environment with natural 3D interaction allows conventional visualization techniques, such as isosurfaces and streamlines, to function as extensions of the user's hands and senses.

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Atmospheric Science

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EQUIPMENT
CAVE

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Stepping Into Reality

This team's current work is focused on embedding real (stair stepper) and computer-generated forces (mechanized and infantry) into a distributed interactive simulation. A virtual environment version of this work produced through stealth imaging is portrayed using the CAVE environment. An individual on the stair stepper can view the virtual environment, move around in it, and interact with other simulation entities by firing a weapon. As a feedback mechanism from the virtual terrain, the stair stepper provides a closer sense of reality.

CATEGORY
Situational Training

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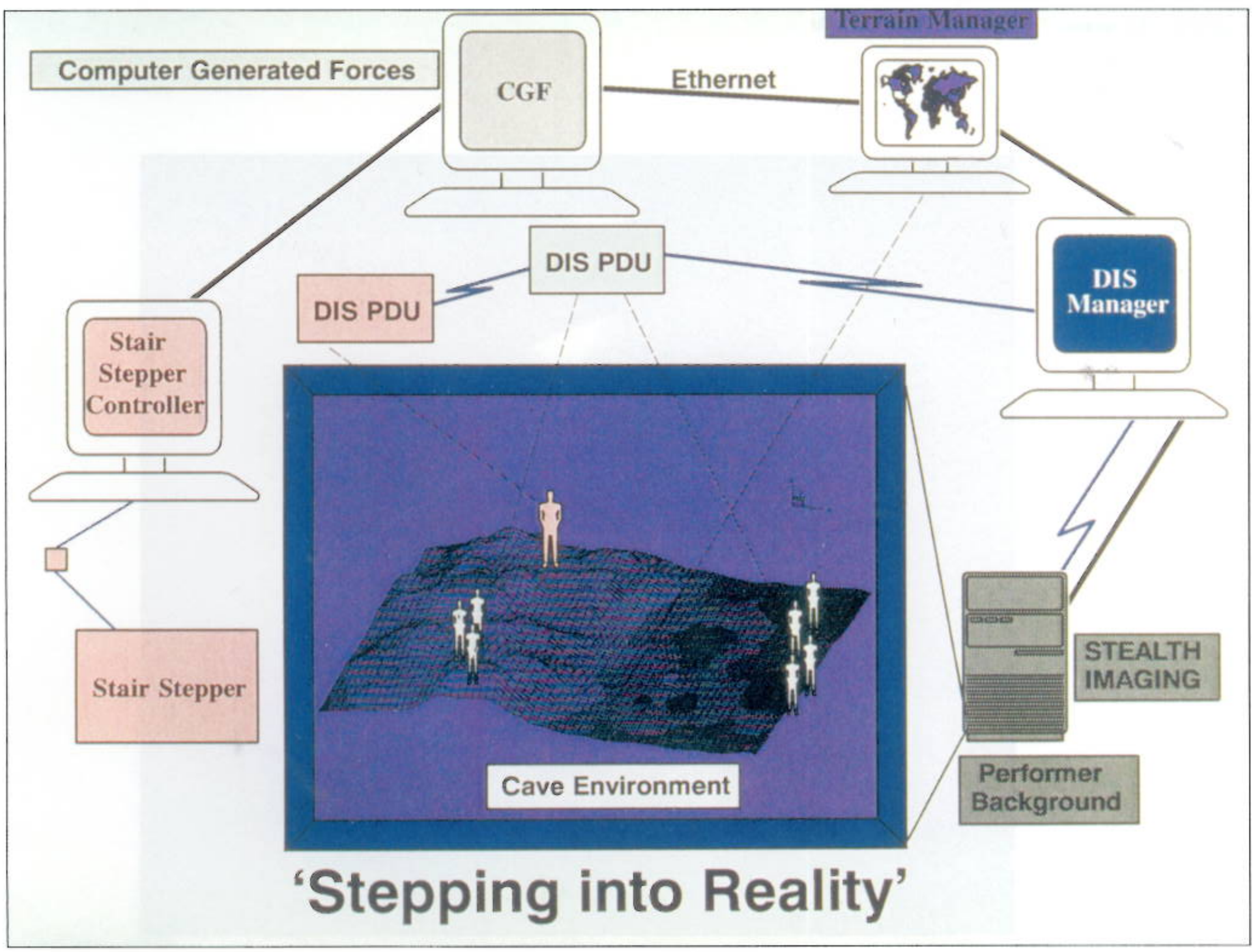

Parallel Real-Time Radiosity

This application demonstrates how parallel architectures are being used to render scenes in real time or close-to-real-time using physically based lighting models (in particular, radiosity). For VROOM, the application visualizes Argonne West's Breeder Reactor model database and other interior room scenes.

Virtual reality is helping to determine which components of global illumination models are important to provide users with a level of realism beyond standard lighting models. Implementing the algorithms for radiosity and other physically based techniques in virtual reality helps focus the work on the areas that are most in need of improvement – for example, performance enhancements using parallel architectures, better modeling of the physics of light transport, human perception issues, and other areas.

CATEGORY
Algorithms

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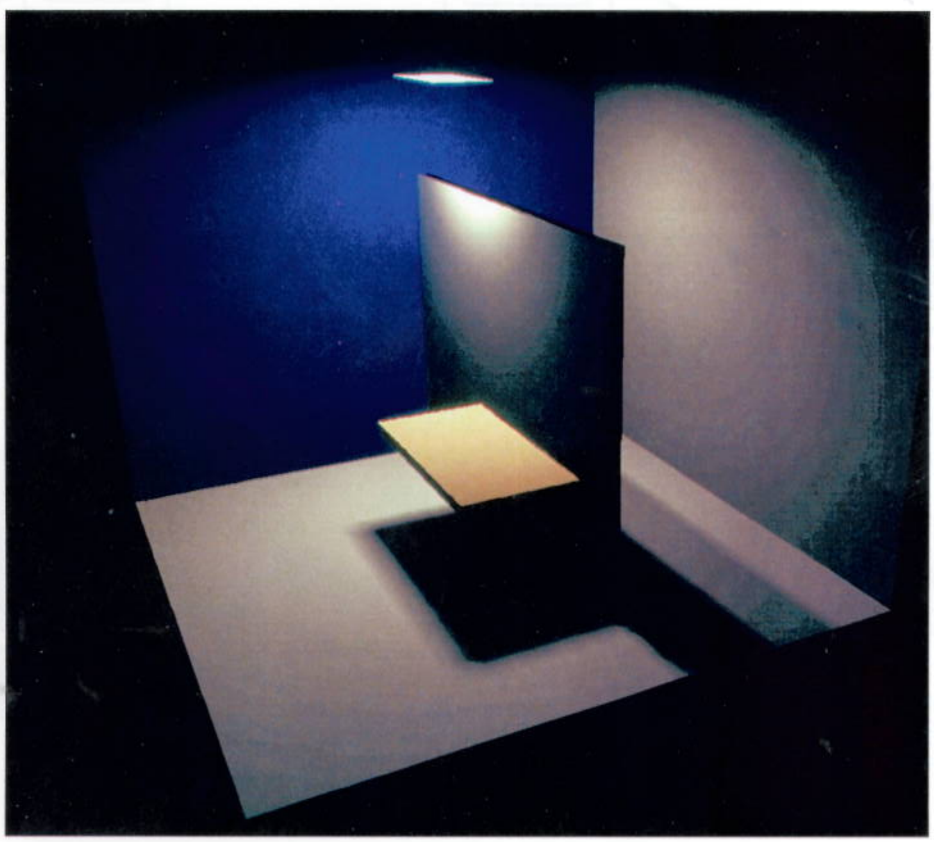
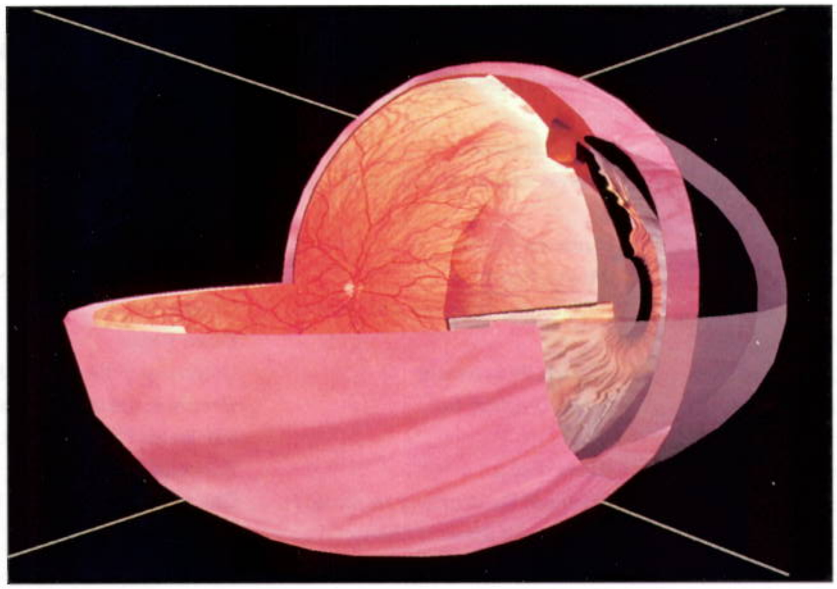


The Virtual Eye



This project demonstrates the design of an anatomically realistic computer model of a human eye in a virtual environment. Users are able to explore and interact with the eye's components to discover their characteristics. The model will eventually be used to educate students on the eye's geometry and will allow them to simulate common presurgical procedures.

CATEGORY
Medical Imaging

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JASON Interactive Mapper

The JASON is an underwater remotely operated vehicle operated by the Woods Hole Oceanographic Institute. This virtual-reality demonstration re-enacts the exploration of hydrothermal vents in the Guaymas Basin near Baja California. CAVE participants watch the JASON as it collects bathymetry data, temperature data, and high-resolution still images, and transmits a "live feed" from its video cameras (pre-recorded, in this case, for presentation purposes).

With a virtual-reality interface, users are able to visit this normally inaccessible region via telepresence. After they watch the JASON explore the vents, users construct a 3D map from what they have seen, physically placing icons that represent observed objects and events into the virtual environment.

CATEGORY
Oceanography

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Evolution of Behavior in a Simulated Environment

This application enables CAVE users to view and interact with the behavior of various animats, virtual animals that exhibit behaviors similar to those of natural animals, such as predators, scavengers, or gatherers. The user interacts with the animats by giving distinct behaviors rewards or penalties that affect the life of the animat and its future generations. The fundamental notion of the application is based on the field of Artificial Life, the study of living organisms through artificial means.

Virtual reality enhances this simulation by providing users with immediate feedback on various behaviors. Behaviors should be easily recognizable and users should be able to determine if the behaviors are similar to what is expected. The visual feedback is different from traditional text-based results.

CATEGORY
Artificial Life

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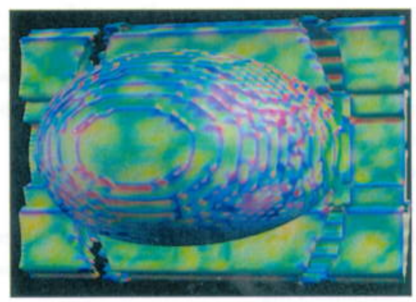
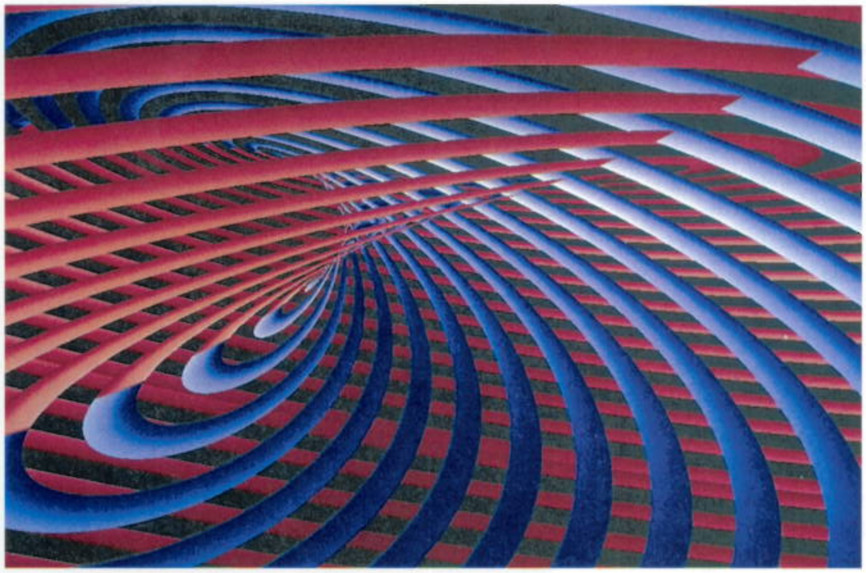


Getting Physical in Four Dimensions



The goal of this application is to provide a more intuitive understanding of hyperspace. It enables users to physically interact with objects in four dimensions.

A series of classical 4D objects is projected into the 3D CAVE through simultaneous projection of both 3D slices and perspective projection. There is also a mode that enables the user to directly draw 4D surfaces of revolution by drawing a 3D curve. The user controls both the 4D projection point and the 3D viewing point, in addition to rotation and translation, in four dimensions.

A sub-cultural goal of this project is to enable users to develop an intuitive understanding of hyperdimensional worlds. Human beings have learned about the 3D world in which we live by manipulating objects within it. In this project, the goal is to let people directly manipulate 4D objects in four dimensions. Previously, 4D objects were projected into three dimensions and then into two dimensions for viewing. Virtual reality allows a much more 3D environment, minimizing the effects of 3D-to-2D projections. It also creates a more physical interface to the 4D objects and their projections and transformations, which gives participants better intuitive insight into four dimensions.

CATEGORY
Mathematics

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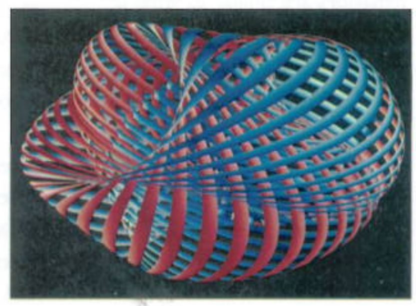

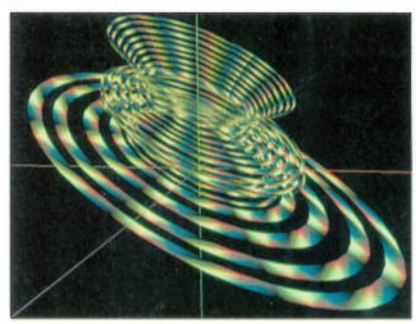

Virtual Director

Virtual Director provides a user-friendly, virtual-reality method to control camera motion for instant playback or animation recording. The Virtual Director shown in VROOM is a camera motion-control application using the CAVE to control and play back users' input in real time. Stored camera-motion data can be used to control various computer-generated imagery cameras (e.g., Wavefront, AVS, Renderman, etc.). This demonstration also includes an astronomical simulation of colliding galaxies that has been fully rendered in batch mode with this kind of camera motion control in mind. The galactic data were simulated using a supercomputer and visualized with Wavefront.

Historically, controlling camera motion has been one of the most clumsy aspects of computer animation. When camera motion is recorded and played back using virtual reality, the control mechanism is much more user-friendly and natural for novice users than attempting camera control with traditional methods. Virtual reality facilitates the real-time interface for camera motion viewing, recording, and playback. This application is robust and can be applied to various 3D imaging settings as well as scientific datasets.

CATEGORY
Algorithms (animation production and recording)

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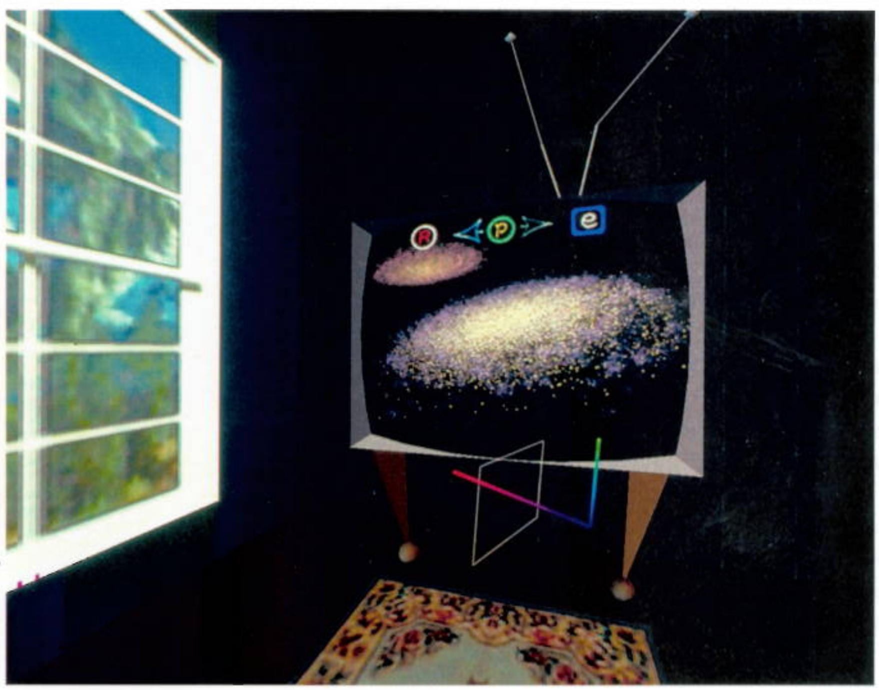
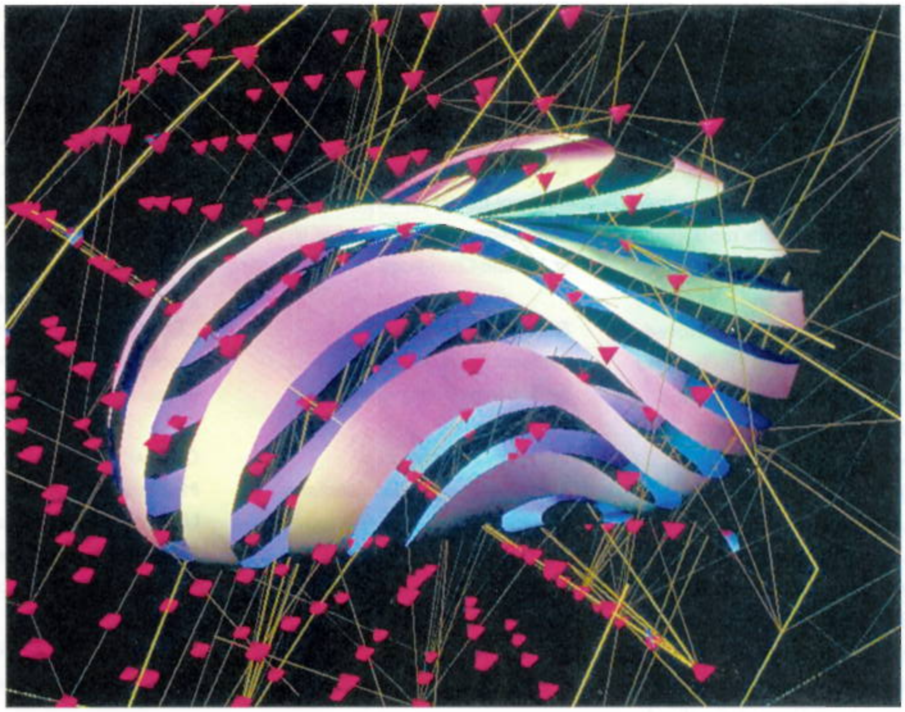


Topological Surface Deformation



The CAVE's immersive virtual environment enables participants to walk around mathematical shapes, step through complex surfaces, or move a surface through itself. Virtual reality encourages users to see shapes from a new perspective – from the inside, looking out – and to explore and manipulate complex surfaces in order to better understand them.

Topology is the study of the characteristics of mathematical surfaces, such as their number of sides, edges, or holes. This program uses free-form deformations to study the topology of mathematical surfaces. Deforming a surface changes its shape, but not its characteristics; an edge remains an edge, and a hole remains a hole, no matter how distorted the edge or hole appears. The claim of topologists that a donut (torus) and a coffee cup are topologically equivalent is one of the deformations demonstrated in this program.

CATEGORY
Mathematics

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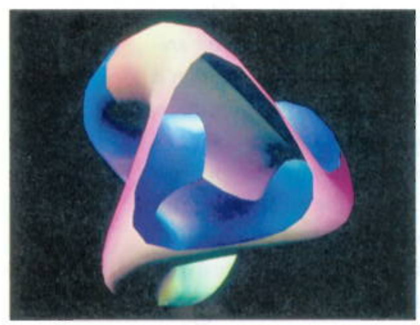

Virtual Reality for Parallel Computer System Performance Analysis

Recording and analyzing the dynamics of application programs, system software, and hardware interactions are the keys to understanding and tuning the performance of massively parallel systems. Because massively parallel systems contain hundreds or thousands of processors, each potentially with 5-10 dynamic performance metrics drawn from multiple system levels, the performance data occupy a very sparsely populated, high-dimensional space. Understanding the dynamic "shape" of multiple performance data metrics in a high-dimensional space is only possible if one can examine multiple projections of this space.

The ultimate goal of this performance data immersion project is performance optimization and control of massively parallel systems. Not only does data immersion allow one to quickly grasp the relationships among large numbers of performance metrics, but by causally tying a metaphor in the virtual environment to a performance data source in the system or application code, it also allows the observer to intuitively realize real-time, adaptive control of system or application performance.

Category
Performance Analysis

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Equipment
CAVE

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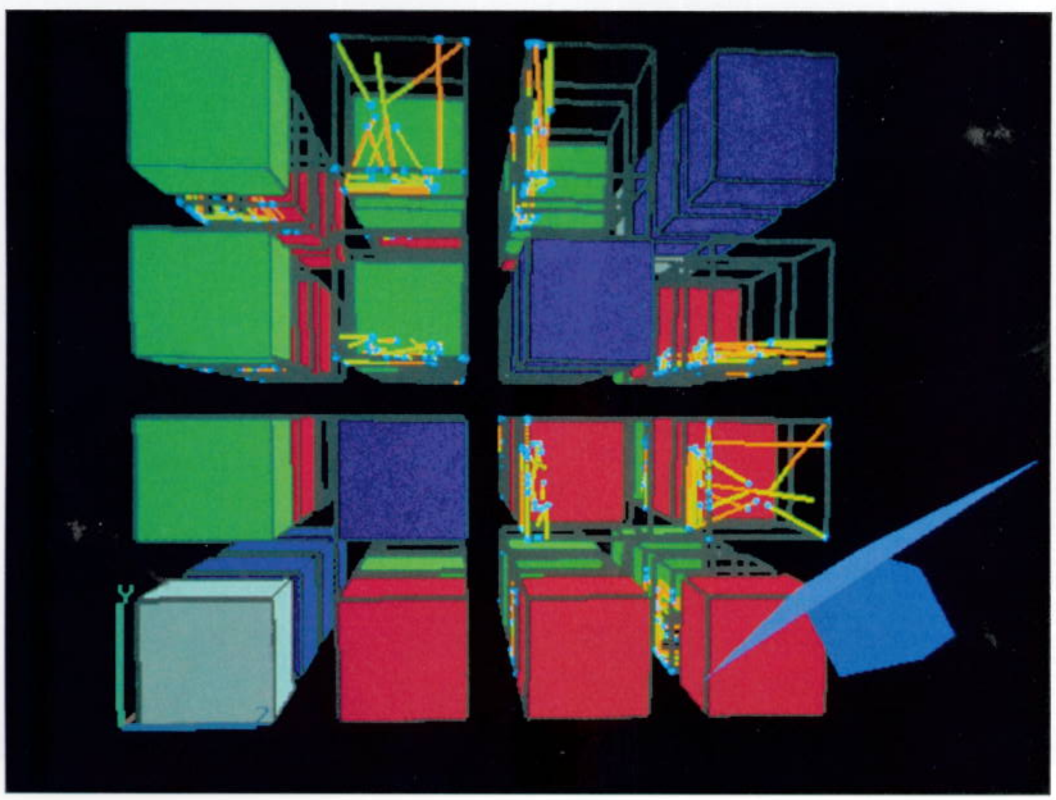

Computational Modeling for Crash-Worthiness of Electric Vehicles Using Nonlinear Finite Element Methods

This project uses transient nonlinear finite element analysis to model the crash-worthiness of a vehicle modified from gasoline to electric power. The modification changes the dynamic structural response of the vehicle during a collision, and designers must ensure occupant safety as the vehicle components undergo plastic deformation. Finite element models allow investigation of the deformed geometry and buckling patterns of the vehicle over a series of time steps. They also permit examination of key response quantities such as effective stress and effective plastic strain.

CATEGORY
Engineering

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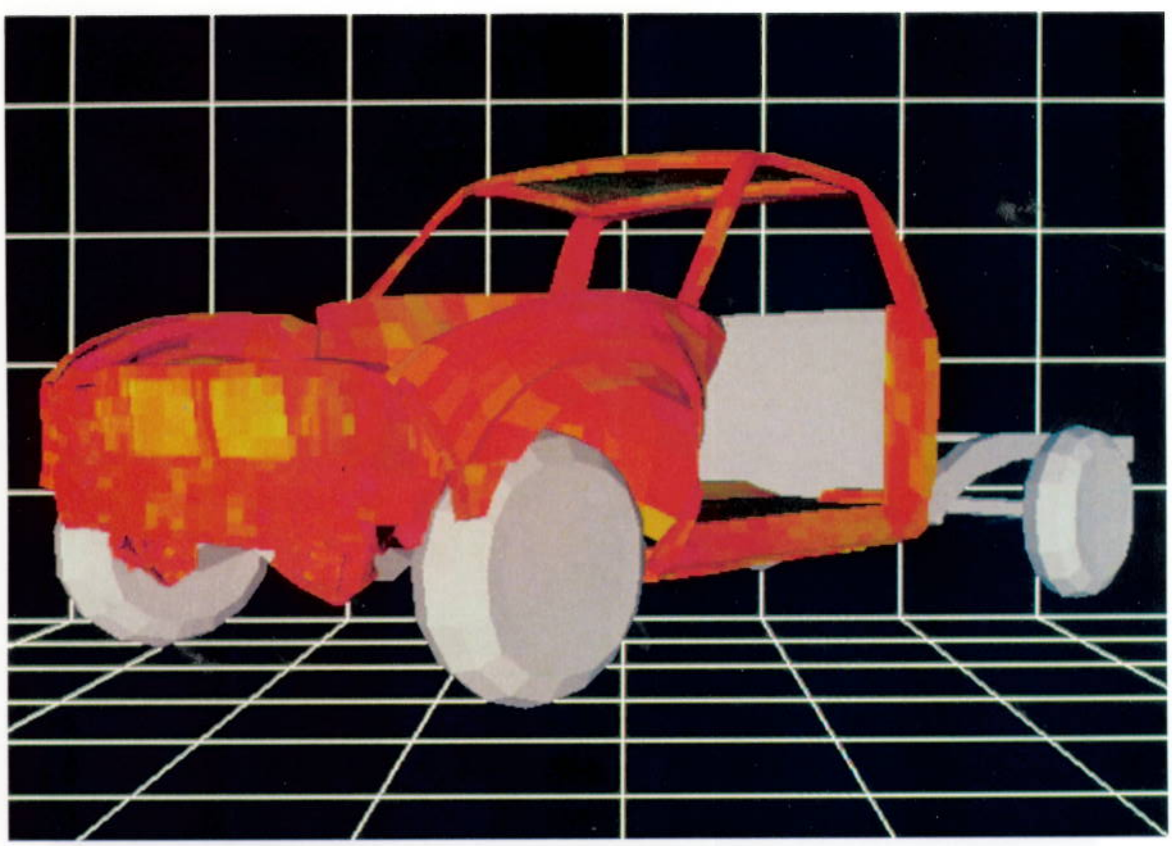
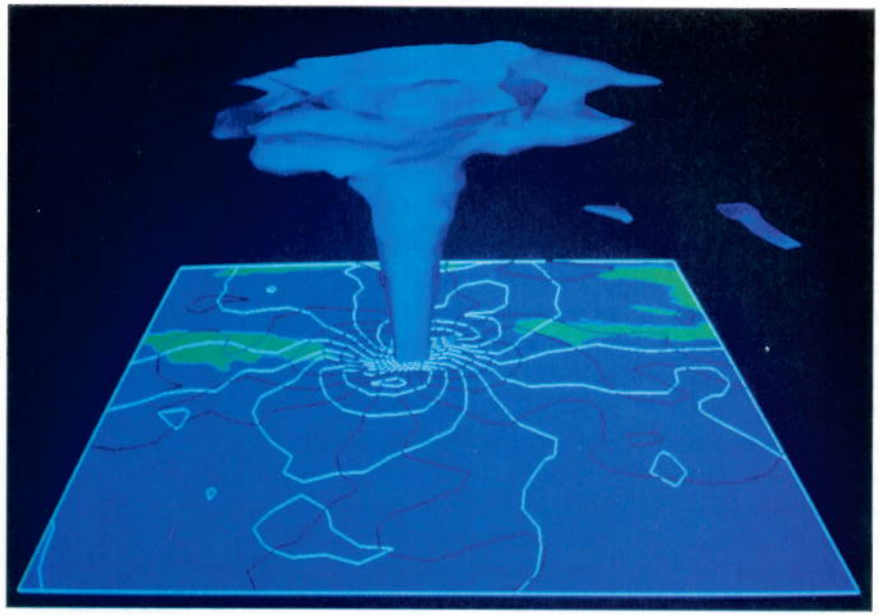


The SIGGRAPH 94 Daily Weather Forecast



Interactive 3D visualization has proved its value for finding and understanding problems with numerical simulations of the atmosphere. Scientists are able to scan through large simulations quickly, looking for problems, and then trace back through simulated time to find the root causes of those problems by comparing different model fields and looking at the geometry of those fields from various angles.

This project demonstrates the current two-day forecast of Florida weather, made with the UW-NMS modeling system and visualized using the VIS-5D software. Virtual reality is used to present the high spatial and temporal resolution of numerical weather forecasts.

CATEGORY
Atmospheric Science

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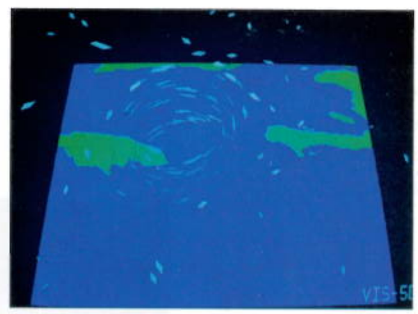

The SANDBOX: Scientists Accessing Necessary Data Based On eXperimentation

Scientific databases contain enormous amounts of data collected through experimentation. They are accessed by investigators from many disciplines, most of whom are unfamiliar with databases and their associated query languages. Using the SANDBOX, an investigator places virtual instruments into a virtual reenactment of the original experiment and collects data from the scientific database in much the same way that the original data were collected.

This prototype of the SANDBOX allows an investigator to access parts of NASA's FIFE scientific database, which contains data from ground experiments, airborne instruments, and satellite photographs for developing ways to measure surface climatology from satellite information.

CATEGORY
Earth Science

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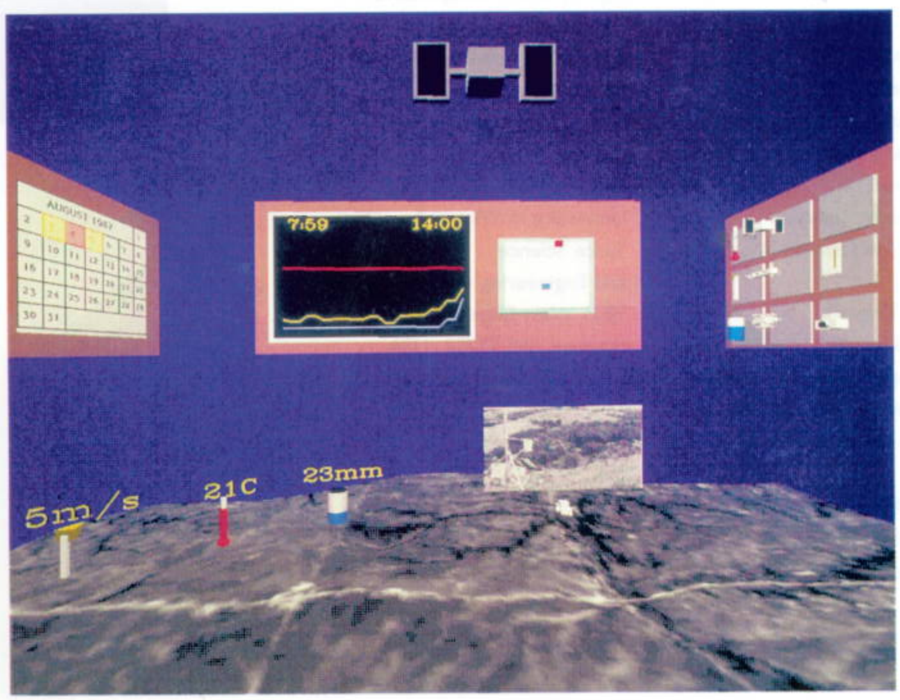

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