The New York Times | https://www.nytimes.com/1988/10/30/us/supercomputer-pictures-solve-the-once-insoluble.html

Supercomputer Pictures Solve the Once Insoluble

By John Markoff

Oct. 30, 1988


The New York Times

Supercomputer Pictures Solve the Once Insoluble

WHITE HOUSE RACE NEARS END MARKED BY MORE ATTACKS

Any Sale in U.S. Of Abortion Pill Still Years Away

TV's Role in '88: The Medium Is the Election

Integration Proves Elusive in an Ohio Suburb

Israel Faces Crucial Election and Apathetic Public

Suddenly, the Race Is Close in Canada

See the article in its original context from October 30, 1988, Section 1, Page 1 Buy Reprints

VIEW ON TIMESMACHINE

TimesMachine is an exclusive benefit for home delivery and digital subscribers.

About the Archive

This is a digitized version of an article from The Times's print archive, before the start of online publication in 1996. To preserve these articles as they originally appeared, The Times does not alter, edit or update them.

Occasionally the digitization process introduces transcription errors or other problems; we are continuing to work to improve these archived versions.

Describing how a tornado forms in a thunderstorm racing across a prairie is a most complex scientific problem, requiring dozens of separate mathematical equations. Solving the equations would create an answer requiring millions or billions of numbers. Today, researchers are using pictures and movies to dramatically simplify their answers and to give new insights into the formation of tornadoes.

The tools that make it possible are powerful supercomputers. Using them, scientists can convert numbers into remarkable images that appear as two-or three-dimensional color pictures or movies on computer screens. A picture of clouds, for instance, can be manipulated on a computer screen so that scientists can see the details of how a violent tornado is formed.

The recent wave of developments in supercomputer graphics has enabled scientists to explore previously uncharted areas of knowledge: from the formation of tornadoes to the behavior of transistors to the workings of a single neuron in a cricket's brain.

With the computer-generated pictures, researchers can easily recognize hidden patterns that could never be found in the huge columns of numbers that have been the basis for scientific research in the past. Scientists have long used illustrations and charts to display their findings, but complexity of modern scientific problems and the reams of data generated by supercomputers have forced them to rely on computer graphics to simplify these puzzles. Images Instead of Numbers

Scientists say the use of images instead of numbers has produced a fundamental change in the way researchers think and work.

''The human brain is the best pattern recognizer in history,'' said Heinz-Karl Winkler, a Los Alamos National Laboratory physicist. ''We can use it to visually scan vast quantities of data. We can zero in on a structure in an image and distinguish between important things and unimportant things.''

It was the huge quantities of data, some generated by the supercomputers themselves, that led to the use of the machines to visualize the data with the aid of computer graphics rather than pore over endless columns of numbers. 'Intuition From Pictures'

''People have a lot easier time getting an intuition from pictures than they do from numbers and tables of formulas,'' said Stephen Wolfram, a physicist who formed Wolfram Research Inc. to develop a software tool to permit mathematicians and students to view equations as three-dimensional images.

''In most physics experiments the answer used to be just one number or a string of numbers,'' he said. ''In the last few years the answer has increasingly become a picture.''

Just a few years ago, supercomputers were rare, and only nuclear weapon scientists and a few others had access to them. But the number of the largest machines has grown significantly. And at the same time a class of smaller ''desktop supercomputers'' specially designed to display graphics has appeared. These machines, manufactured by companies like Ardent Computer Corporation and Pixar Inc. in California and Stellar Computer Inc.

in Massachusetts, are designed to provide a window into a more powerful supercomputer by displaying its output.

The applications of the rapidly developing scientific visualization field are proving to be widespread.

At the University of Illinois, scientists have visually modeled a transistor. By peering inside this basic building block of modern electronics, they have been able to watch it switch on and off. The researchers were startled to discover that the switch turns off much faster than it turns on, something that had not been theoretically predicted. The researchers did not actually look inside a transistor. But by feeding enormous amounts of data on transistor behavior into a supercomputer, the machine was able to create a three-dimensional simulation of a transistor and allow the researchers to manipulate the image so that it would show what the inside would look like.

Medical researchers at the University of Colorado have been painstakingly cutting a human cadaver into half-millimeter-thick slices and converting the image of each slice to digital code. The results, when reassembled with a graphics program, will provide the first three-dimensional view of the human body that is of photographic quality. Doctors will be able to peer into the human anatomy with a precision not previously possible, researchers in charge of the project said.

By using a similar technique, scientists at Johns Hopkins University last year found a previously undiscovered bone in the hand of a sea otter, explaining for the first time where the otters get the strength that permits them to pry abalone shells off rocks.

At the University of Illinois again, an atmospheric scientist, Robert B. Wilhelmson, has developed a three-dimensional model of a thunderstorm. The animation shows a vast, roiling cloud of rain rushing across a prairie. Dr. Wilhelmson hopes that with the added computational power that will soon become available with the introduction of the Cray III, the next generation of the most powerful supercomputer, he will have enough resolution to simulate the formation of a tornado inside the storm.

Physicists at Los Alamos National Laboratory have explored the use of graphics displays as aids to view the progress of a supercomputer solving partial differential equations, a class of mathematical problems. Scientists will be able to control a program while it is running a series of the equations, directing the computer to focus on certain portions of the problem and thereby speeding its solution.

At the University of California at Berkeley, neurobiologists have constructed a detailed model of a single neuron in a cricket's brain. By first tracing the circuitry of the neuron

under a microscope and building a computerized map, they have been able to reconstruct a functioning model of the neuron on a computer screen. Equations that represent the neuron have permitted the researchers to model how it computes wind velocity and direction and then passes the information to other centers in the cricket's brain.
Laboratory of the Future

Many experts in scientific visualization predict that powerful computing aids will increasingly replace traditional laboratory equipment. They might permit researchers to spend more time thinking purely about science and less time worrying about the mechanics of experiments.

''In the future, what you want to do is to make the computer a colleague,'' said Larry L. Smarr, an astrophysicist who directs the National Center for Supercomputing Applications in Urbana, Ill. Dr. Smarr envisions a laboratory environment in which technologies like artificial intelligence and voice recognition will augment the power of the supercomputer to provide a ''scientist's apprentice'' - a machine that will act like an intelligent laboratory assistant, performing any experiment the scientist thinks of.

''What you would like to do in 1998 is basically tell your computer: 'I've got this interesting new data from Cal Tech today. I have a hunch it's a big black hole swallowing up a little one. Why don't you give me an initial image for a mass ratio, say 10 to 1, and place them six radii apart? Now spiral them together.' Then you watch the simulation.''
First Efforts in Visualization

That vision of the future stands in a striking contrast to Dr. Smarr's first efforts in visualization.

In 1977, while at the Lawrence Livermore Laboratory in Livermore, Calif., Dr. Smarr was doing research attempting to test Einstein's general theory of relativity. He wanted to visualize how the mass of a black hole might curve space, as Einstein predicted. Because supercomputers, powerful graphics programs and personal computers did not exist then, Dr. Smarr first plotted his data on paper and cut the paper into long strips. He then had a party, and with the help of his graduate students wove the strips together to create a three-dimensional image.

''In my mind's eye I could imagine what it looked like qualitatively, but I had no way to couple from the numbers to the image,'' he recalled. ''The resulting shape in the paper simulation looked just like the one I had in my head, but I could see it change in my mind.''
Far-Reaching Impact

The need to see the numerical output from a powerful supercomputer has had a far-

reaching impact, creating a new style of computing. Images, and frequently images that are animated, have quickly become the standard fare of the supercomputer world.

Because the ''scientist's work station'' of the future is not yet a reality, researchers frequently spend more time developing new software tools than conducting basic science. Some are concerned that this ''tool building'' may distract scientists from their real mission. Moreover, some physicists have argued that it is a loss to the field when theoretical physicists like Dr. Wolfram of Wolfram Research, widely regarded as a brilliant scientist, spend their time on computer science problems.

But Dr. Wolfram argues that in recent years many of the most exciting ideas in physics have come from computational science. ''I don't share the snobbishness of some of my pure-science colleagues who think that computer science is a lighter thing to be doing than basic physics,'' he said. 'Renaissance Teams'

To permit scientists to continue to focus primarily on science, the National Center for Supercomputing Applications has created interdisciplinary groups it calls ''renaissance teams,'' an approach to research that unites the scientist with a graphic artist and a computer programmer to solve a problem.

These new scientists' assistants bring traditional artists' tools, such as shading and color, to bear on the oceans of numbers that spew from supercomputers. These assistants also bring their artistic intuition and creative expression to a world that has previously been viewed as dry and regimented.

In several cases, the new visualization technology has breathed new life into previously moribund scientific disciplines. At the the University of Colorado Health Sciences Center in Denver, where researchers are studying the cadaver, interest in the study of the anatomy has been revitalized. 'A Tremendous Coup'

''With the new tools, we have succeeded in generating new interest in the study of anatomy,'' said Dr. Victor M. Spitzer, a researcher in cellular and structural biology. ''It's a tremendous coup.'' University of Colorado researchers have so far created images of a knee joint and a pelvis. When the entire human anatomy is captured, it will be possible to selectively make layers of the body translucent so as to view internal organs or to peel away layers so as to permit viewing the skeleton or the arterial or nervous systems in isolation.

Dr. Spitzer said that plans call for working with researchers at the National Aeronautics and Space Administration to use a supercomputer to calculate muscle movements in order to add proper anatomical motion to the three-dimensional image. Does Not Replace

Talent

Scientists stress that the new computational science augments rather than replaces talent and intellect. Karl Hess, a semiconductor physicist at the University of Illinois, tells of receiving a graduate thesis from a student with the last name of Arnold who used a Cray supercomputer to rework the theories of William Shockley, the co-inventor of the transistor.

''This first-rate student had done an excellent job, and he had a graph that showed his research yielding far more precise data than Shockley's,'' recalls Dr. Hess. ''He had labeled one curve representing his data 'Arnold' and another 'Shockley.' ''

Dr. Hess made a notation on the thesis before he returned it to the student: ''Wrong - Arnold plus Cray.''

A version of this article appears in print on , Section 1, Page 1 of the National edition with the headline: Supercomputer Pictures Solve the Once Insoluble