The Digital Art: "Cray-1"
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The future of reality occupies about 70 square feet of floor space in a vast converted warehouse on La Cienega Boulevard in Los Angeles. It is called Cray-1 and it is the world's most powerful supercomputer. There are 40 supercomputers in the world; 34 of them are Cray's. They cost from $ 10 million to $ 20 million. Their users are the largest and most powerful organizations on the planet such as the Department of Defense, and Exxon. But the anonymous unmarked warehouse in which this machine resides is not some secret operation of the Pentagon; it is the home of Digital Productions, a new company founded by computer animation pioneers John Whitney, Jr. and Gary Demos to produce the world's first feature-length motion pictures entirely simulated by computer.

Whitney, 36, and Demos, 31, are already legendary figures in the world of digital scene simulation, having literally pioneered the field (and coined the term itself) at Information International Inc. better known as Triple I—in 1974 when computer graphics were all but unheard of. Most of the work they produced there can be seen in Triple-I's now-famous 1981 Sample Reel—including Adam Powers, the film's eerily-realistic juggling, top-hatted master of ceremonies, regarded unanimously as the finest work of simulation of its kind ever produced. They also created the preliminary tests which demonstrated the viability of TRON two years before the project was sold to Disney.

By that time, however, Whitney and Demos had left Triple-I to form their own company, driven by a bold, almost Promethean vision—they would transform the future of cinema and reality by creating narrative feature films that were 100 percent simulated. It would take two or three years of software and hardware development to reach that point. Meanwhile, they would mass produce special effects of such realism that audiences would be unable to distinguish live action from simulation. Based on their pioneering experience at Triple-1, they knew all this would require the power of a supercomputer. So they leased a Cray-1 for $180,000 a month.

It's a 12-sided, hollow semicylinder, only 6 1/2 feet tall and 5 feet in diameter, in which 3400 circuit boards containing more than 200,000 chips are stacked in 12 vertical columns, 288 boards per column. Behind a glass plate in the cylinder's interior, the 67 miles of wire that interconnect the circuits can be seen. Due to the circular arrangement of the components, most of the wires are only a foot long; if they were longer, the propagation of electrical pulses through them about half the speed of light—would slow the machine down. It is this elegant architecture, challenging the fundamental limitation placed on all computers by the speed of light, that makes Cray the fastest computer in the world. With a cycle time of 12.5 nanoseconds (billionths of a second), it cruises along effortlessly at 100 megaflops. That's 100 million floating point operations (such as addition or multiplication) per second. With some computations there's an overlap that pushes its speed to 140 megaflops.

And in short bursts, the machine has been clocked at 250 megaflops.

Speeds such as this generate enormous heat. To dissipate it, Cray's 3400 circuit boards are sandwiched in pairs on opposite sides of heavy copper heat transfer plates that are cooled to 25 degrees Centigrade by compressed Freon pumped through tubes in the frame. This keeps the temperature inside at about 68 degrees, but all that copper brings the weight of the diminutive machine to nearly six tons.

The unprecedented power of the Cray-1 is indicated by the magnitude of the support system necessary to keep it running—100,000 W of power delivered over 36 power lines to generators that step up the 60-cycle power from the street to the 400-cycle AC the Cray uses; a network of cooling lines pumping the Freon gas from compressors in a soundproofed room, and a 100-ton water chiller outside the building that exchanges heat from the Freon after it has circulated through Cray. That's only the power support system; in addition, the Cray Corp. insists that seven highly-paid technicians—four hardware maintenance people and three software experts—be hired along with the machine.

And then there are the communication problems. Mere mortals do not talk directly to a supercomputer. The machines are so fast that it's impractical to adapt them to human time-scales, so "front end" computers—often powerful mainframes in their own right—are employed to interface the supercomputer with the outside world. The front end system at Digital Productions consists of an additional $1 million in equipment, including two Vax 11/780 mini-mainframes. Whereas the computer animation team at Lucas-Film considers a single Vax perfectly adequate for computing all their simulations, Digital Productions needs two of them just to talk to the Cray-1, which is 400 times more powerful than the VAX and a million times more powerful than an Apple-II.

So it's a momentous occasion in the all-white "clean room" at Digital Productions, Whitney and Demos watching the first frames of their first project come up on the 1200-line Ramtek display. The film is Starfighters, a space adventure in the Star Wars tradition, produced by Lorimar. The images are orders of magnitude beyond anything done in this medium before, breathtaking in their detail and photographic realism. In comparison, TRON looks like a pencil test. Unfortunately, Lorimar is unwilling to release the images for publication at this early stage in the production. The art director at Digital Productions, and chief production designer for Starfighter, is Ron Cobb, the '60s political cartoonist whose film credits include Star Wars, Alien, the special version of Close Encounters of the Third Kind, Raiders of the Lost Ark and Conan the Barbarian. Cobb is obviously delighted with his new freedom from the world of modelmaking.

"In traditional cinema you're tied down in every way by the mechanics of moving a camera around in the real world that's governed by gravity and the laws of physics." Cobb said. "Now we'll be able to sever all those ties and generate forms that have never existed. The most important thing to me as a designer is to be able to experience my creations in 3-dimensional space and move them around and observe them as you would look at any object in the real world. That so clarifies your thinking. I have no doubt that it will loom larger and larger in the future and become the basis of a totally new art form."

Digital Productions will produce 45 minutes of simulation for Starfighters in eight months. In terms of volume output and scene complexity, it is the largest computer simulation project ever undertaken by anyone, including the military. They'll average 250,000 polygons per frame—double the complexity of the most detailed images ever produced for scene simulation—at an average computing time of 100 seconds per frame.

Some images will contain a million polygons, achieving absolute photographic realism by anyone's standards. Pictures of that complexity will tax the strength even of the Cray, which might take 10 minutes to compute each one. (By comparison, the mainframes used on TRON occasionally required up to an hour to compute frames one-tenth the complexity.) Whitney estimates the cost will be about $2000 a second or $150 per frame—flatly competitive with the $10 million budget of an average 90-minute feature in Hollywood today.

The Cray's number-crunching brute force combined with sophisticated (and proprietary) "algorithmic database" software that Demos is writing for it, will allow Digital Productions to produce the world's first all-simulated feature-length narrative movies within three years. The simulations for Starfighters are being created by traditional methods that are very time-consuming. Step by tedious step, mathematically-specified angles , surfaces and light sources are combined in the computer to form 3-dimensional, highlighted, textured and shaded renderings of Cobb's original drawings, which can then be moved around in three-dimensional space. "But only if the computer is specifically told where everything should be all the time", Demos explained. "Here in this frame and there in that frame, and this has the z-axis and that has the y-axis and moves such a way at such a pace. Narrative storytelling is impossible with these methods because it requires characters with convincing gestures and personalities, capable of conveying sophisticated, believable emotions like love or fear.

"The simple facial features that work on Disney's flat 2-dimensional cartoon characters are totally inadequate on 3-dimensional shaded simulations. You must have realism, and that's far too complex if you have to specify each little detail. You need to be able to give a command like 'A man walking down the street bouncing a ball', and the program is intelligent enough to know what you're talking about and do it automatically; it knows about gravity and that the ball should roll downhill and so on.

And it'll know generic things like what color streetlights are and how tall they usually are things like that to help you set the scene up more quickly and easily so that story-telling becomes viable."

Towards this goal, Digital Productions has formed a special research team headed by experts in kinesiology and human movement who work with programmers to create "algorithmic databases" that consist of "smart objects". Already they have a "smart shock absorber" on a simulated unicycle that knows how to bounce automatically when it is moved over bumpy terrain. Next they'll build human characters from the skeleton up, whose "smart muscles" will know how to stretch and change automatically when the figure is given a particular movement command.

The visionaries at Digital Productions also foresee operating as a time-shared remote "image utility", offering real-time interactive visual simulation services to the professional community, and ultimately to the general public. "The applications of custom simulation are infinite", said Demos, "and it seems to me the demand would be enormous. Everyone from video production houses to scientists, doctors, architects and designers could use high-quality 3-dimensional computer graphics." Because the Cray can effortlessly generate graphics in real-time video, 1800 subscribers to a dedicated cable channel could be served with a new frame every minute.

Any personal computer can have enough memory to function as a framebuffer, capturing and storing the images to be displayed on the computer terminal or a TV set. Alternatively, Demos notes that framebuffers are expected to cost about $10 by 1985, and could be built into every TV set manufactured.

"I think interactive custom simulation is viable right now", he said. "We could provide television production facilities with real-time animation if they had a way to store the motion at their end. For example, with a local workstation they could work up their action in simple wire-frame graphics and send it to us over phone lines; we'd render it in solid three-

dimensional imagery, highlighted and shaded, and compute the frames as a movie—in real-time if it's not too complex and send it back either over phone lines or a cable channel."

By the end of the decade, when software has been developed for real-time computer animation and cable TV is universal, Digital Productions will offer ultra-realistic interactive video games to the general public.

"You just connect your personal computer to the Cray and tune in the cable channel and become part of the movie", Demos said. "Instead of buying pay-TV movies you pay Digital Productions for interactive movies that you're part of. We present generic possibilities and you create variations based on your personality and abilities. You control things, create a custom movie that will never be seen by anyone else or never do anything else.

"Look at the interest in video games today, even at their low level of aesthetics and interactivity. Our stuff would not be merely interactive, it would be extremely interactive, compared with anything we're imagining today. The more interactive a system is, the more it becomes what you want to be seeing, what you want to be doing, what you want to be exploring. You'll be saying a lot about what you're getting through this system."

John Whitney, Jr. summarized the future according to Digital Productions. "Within this decade, the best in entertainment will be synonymous with high technology. There's no doubt in my mind about that. Feature film storylines will more and more reflect the psychologically compelling nature of computers and electronic games. This will engender entirely new kinds of story writing and filmmaking; new words will enter the vocabulary of visual storytelling and computer imagery will increase in sophistication as the new producers and directors who are now entering the business learn to exploit these powerful tools of simulation. That will attract the best minds and talents of our time and create an enormously intense creative period. We at Digital Productions intend to be part of this new renaissance."