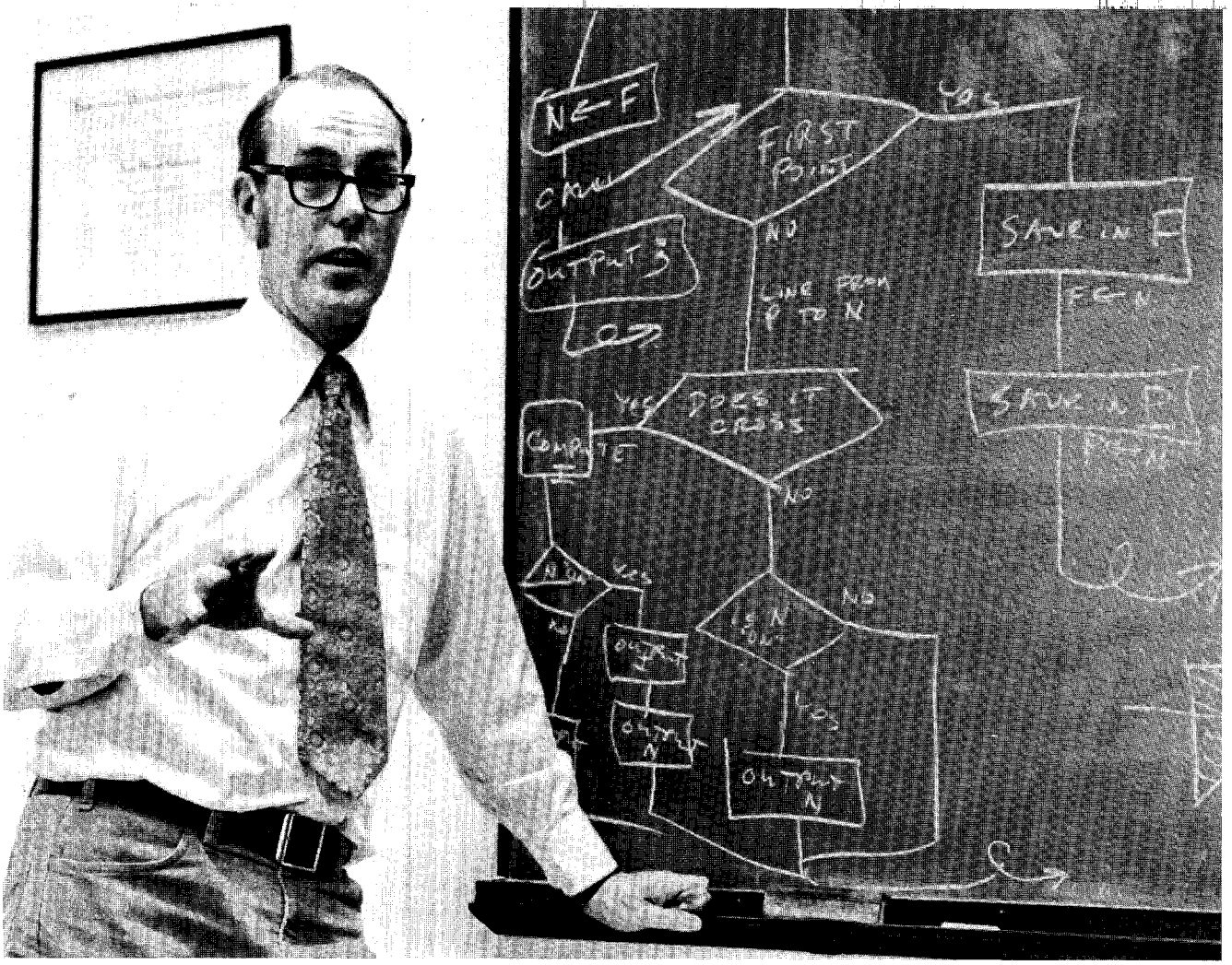


Ivan Sutherland

Computer Science - A Timely Idea

THE WORD most often used to describe an idea whose time has come is "irresistible," and it may be the best word for Caltech's new computer science program too. Some of the components of irresistibility in this case are a handful of enthusiastic faculty members, a group of students who seem to have been born with a gene for computing, and solid administrative support for getting them together. It's a forceful combination.

Both the enthusiastic faculty and the program are headed by Ivan Sutherland, whose preparation for the job includes an educational tour that started with a BS from Carnegie Tech in 1959, an MS from Caltech in 1960, and a PhD from MIT in 1963 — all in electrical engineering and with increasing emphasis on computers. Sutherland's thesis at MIT was on computer graphics, for which he made a widely shown movie called *Sketchpad* that was a milestone in the graphics world.

From MIT he went to Washington, D.C., for three years, ending up as director of information-processing techniques for the Advanced Research Projects Agency (ARPA). That period was a very exciting one in computing. Time-sharing was just opening up, and Sutherland's office was responsible for a lot of major contracts for it. He also traveled extensively and thus got to know most of the people in the mushrooming computer field.

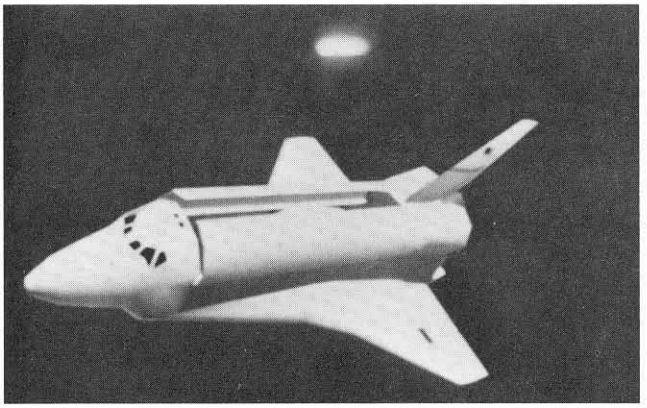
In 1966 Sutherland went to Harvard as an associate professor, and in 1968, with David Evans, he founded a company to make special-purpose display systems for scientific uses. The company, Evans & Sutherland Computer Corp., is located in Salt Lake City, because Evans, who came from an old Utah family, didn't want to uproot his wife and seven children. "Since I had only two children," says Sutherland, "I was the logical one to make the move. Fortunately, my family found Salt Lake a marvelous place to live."

In the next six years Evans & Sutherland developed a remarkable picture-making technology — describing objects in mathematical terms placed in a computer's memory, which then converted them into color pictures. Some of these pictures were so good that it was somewhere between hard and impossible to tell that they were computer-generated. In 1974 Sutherland decided that this technology could be used in the entertainment world to tell stories, so to try out the idea he started another company in Los Angeles. It was "a glorious failure." After about six months, he sold his interest to his partner and went to work for Rand Corporation in Santa Monica, where he did some studies on memory and on microfabrication technology.

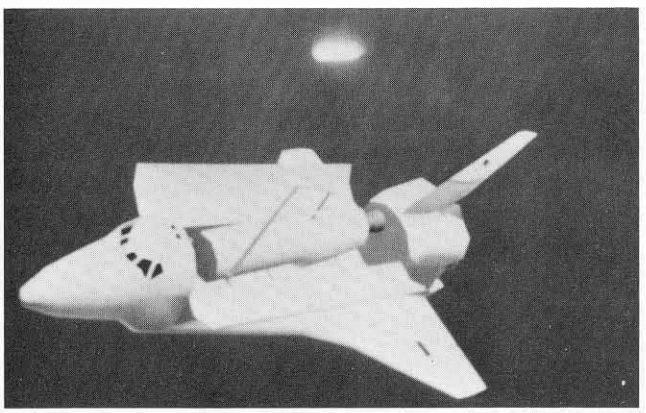
He needed help on these projects from an expert in semi-conductor physics, and Carver Mead, professor of electrical engineering at Caltech, turned out to be that person. It was an exciting and productive association from the beginning, and turned the thrust of Sutherland's interest from computer graphics to the possibilities of Mead's specialty — integrated circuits. So, when Sutherland was offered a faculty position at Caltech in which he could work to develop a computer science program that could build on Mead's expertise, he was delighted to accept. He was on campus on a part-time basis last year, and is now here full time.

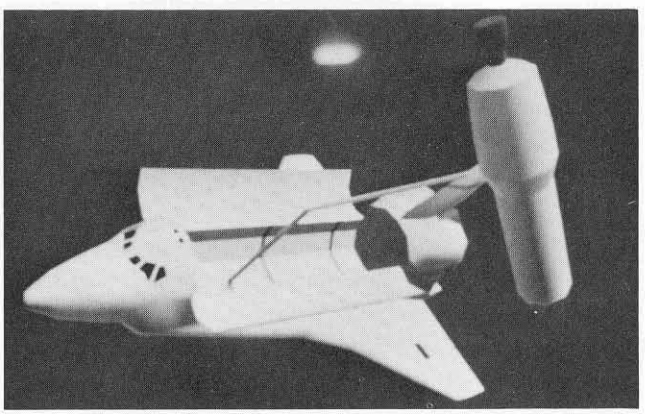
At age 38, Sutherland is one of the young men who has grown up accepting the computer in the same way the members of the previous generation accepted airplanes. He is interested in their development, excited about their potential, and thoughtful about their implications. "In part," he says, "a computer is an end in itself. By reflecting on how computers do things, we are able to learn some things about the nature of knowledge. Learning what is ultimately computable — and what isn't — is a scientific activity in its own right. But using computers is also an engineering activity because of its importance to a lot of other things, from economics to design."

Computers have, of course, been developing for 30 years, and computer science programs are nothing new in college curriculums. Caltech's new program will certainly build on what others have learned, but it will also make maximum use of the Institute's own very special capabilities. The focus will be on the relationship between hardware (roughly, the physical components of a computer) and software (also roughly, the collection of information in a computer's memory) through the medium of the design of integrated circuits. As a matter of fact, the distinctions between hardware and software are fading, partly because of advances like integrated circuits.



Designing a computer simulation of the space shuttle to train NASA crews in payload and assembly tasks takes experts in computer graphics. The recent construction of such a machine by Evans & Sutherland Computer Corp. is the culmination of a 15-year effort in the field — an effort to which Ivan Sutherland has made major contributions. The company built a special-purpose digital computer to synthesize the system's pictures from a mathematical model of the shuttle, and added some assumptions about the direction and quality of illumination. The three photos on this page (taken directly from a standard TV monitor with a hand-held 35mm camera and made available to us through the courtesy of Evans & Sutherland) are part of a series that changes in real time as a simulation of the payload delivery mechanism changes the position of the simulated boom. A large special-purpose computer is required to generate pictures of this realistic action fast enough to observe motion as it happens. The system is now installed at NASA headquarters in Houston.





In brief, an integrated circuit is a way of placing — by a photographic process — a very large number of components on a very small piece of silicon at a very reasonable price. The digital watch and the pocket calculator are two results of the remarkable development of this technology in the last 10 to 15 years. Sutherland feels there is another 10 or 15 years of technological improvement ahead for integrated circuits, which will make them three or four orders of magnitude more complex and exciting than they are today.

Currently, the maximum number of circuits that can be placed on a silicon chip smaller than a fingernail is 20,000, but no one in the business boggles at the idea that the number will soon rise to a million. There is, of course, a limit to how small a circuit can be made, but it is not unreasonable to expect that eventually a single chip in a wrist watch will have all the power of today's biggest computers.

That raises a lot of questions. To Sutherland, answering them is what computer science at Caltech is all about. How do you build that kind of computer? What do the properties of silicon have to do with the eventual form of such a machine? What are the geometric complications? Anything that small can't have very many wires connected to it, so what kind of computations can you do with it? In fact, in a much larger sense, if you had one, what would you do with it? What could it do for you? One not-so-fantastic answer Sutherland envisions is having a machine in his office that would take over many of the tasks of a secretary — keeping his appointment book and reminding him of dates, besides handling the normal computer business of computations. It would probably have a written display output, but perhaps it would also be able to listen to oral communication — and to respond in kind.

How is Caltech going to contribute to this? By its special approach to computer science, which is based on outstanding capability in the design of integrated circuits. Thanks to the work of Carver Mead, Sutherland says, "Caltech is far ahead of any other school in this proficiency. We also have a body of students who realize that integrated circuits are not black magic, but can, in fact, be designed by ordinary humans using perfectly understandable design techniques. It's not easy, because sheer numbers of parts introduce difficulty even if all the physics of the system works. But that, too, is what computer science is about — the understanding of complexity, and then simulating in a computer what we have learned."

At the moment the computer science program has a faculty of three full-time professors: Sutherland, Mead, and Frederick Thompson, professor of applied science and philosophy. Thompson is an expert in languages and information-retrieval, which is a very important part of understanding how to use computers. There are two research associates: Dan Cohen, whose special field is design of algorithms for hardware and who spends full time in computer science; and Bozena Thompson, who spends much of her time in linguistics for the humanities.

Sutherland has recruited three "terrific" part-time people to help broaden the curriculum this year. During the fall term Robert Sproull and Alan Kay of Xerox Palo Alto Research Center spent a day per week each on campus — teaching computer graphics and philosophy of computers respectively. Sproull is co-author of the leading text in his field. Kay's course draws together ideas on human creativity, representation of knowledge in computers, and input/output techniques, which he has put together in building the best "personal" computing system available today. Steve Caine, president of Caine, Farber and Gordon, a commercial programming enterprise in Pasadena, brings to his advanced programming class the lessons of practical experience.

In addition a number of faculty from other departments of the Institute are a part of the teaching program: Charles Wilts, for example, professor of applied physics and electrical engineering; Gilbert McCann, professor of applied science; and Charles Ray, who is lecturer in applied science and director of the Booth Computing Center.

The program has openings for one senior professor and three assistant professors, and Sutherland is delighted with the interest expressed by a number of top-notch people that he's interviewed. Once those jobs are filled, the program can just about double in size and scope. There are 15 graduate students at present, and a great number of undergraduates take the courses. Computer science is a part of the engineering science option, but if things go as planned, it may soon be offered as an option in its own right.

"All we need," says Sutherland, "is people, research money, equipment, and time. But I think it's all going to happen. Right now we're working on a cooperative research program with industry, we're recruiting people, and we're trying every source we know for research money. In 1976 people can really see the relevance of our work in integrated circuits, so we're getting a tremendous response."

If you add that kind of optimism to the hard work that Sutherland and his colleagues are putting into it, computer science at Caltech could indeed be irresistible. □