Oral History of Alvy Ray Smith

Interviewed by:
Dag Spicer

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Dag Spicer: Good morning. It's May 27, 2010. We're here at the Computer History Museum in Mountain View, California with Dr. Alvy Ray Smith. And Dr. Smith, thank you for being with us today.

Alvy Ray Smith: My pleasure!

Spicer: I'd like to start with your earliest days growing up as a boy. Just some of your early years to see how you became the man you became. And so where did you grow up and what did your parents do?

Smith: I grew up in New Mexico. One of my influences, early influences was my artist uncle. Now this is in New Mexico, very western-cowboys-and-Indians-and sheep -and-cows-everywhere kind of place. And an artist was an unusual person. And to have one in the family, turned out to be really important to me. So I grew up in two towns: Clovis, New Mexico, which is a farm town; and Las Cruces, New Mexico, which is an old Spanish village on the Rio Grande, next to the beautiful Oregon Mountains, and separated by them from by White Sands Missile Range, another important influence. I grew up with missiles going off. I heard the first A-bomb go off, it turns out. I was born in '43, so I was two, and my mom said I heard it go off in Las Cruces, which was probably a hundred miles away from Trinity's site, direct line. So I grew up with high tech everywhere and art.

Spicer: I was going to say, so when you grew up, did you have an interest in science?

Smith: Oh, yes! It was because of all—I was in the middle! In fact, I thought everybody grew up with rockets going off, so math and science were really big deals to me growing up.

Spicer: Did you have any artistic hobbies?

Smith: I'm not sure, my dad used to sketch, too, but I drew all my life, and I would paint pictures, and I was in my hometown just like week as a matter of fact, Clovis, New Mexico, and uh…getting an award for Outstanding Graduate from Clovis High School.

Spicer: Oh, that's nice.

Smith: My band director was there, and I said, "Norville" [?], how I want to thank you. You're the man who commissioned my first piece of art." He did. He asked me to come up with some painting about jazz. And so I came up with this abstract that, to me, meant jazz, and he hung on the walls of the band hall of Clovis High. And it was there for years, apparently. I'm glad it's gone, because I'm sure I'd be very embarrassed by it by now.

Spicer: And so you pursued electrical engineering after high school, what drew you to that?

Smith: Well, not because I loved electrical engineering so much, but I figured out I could get more math and more physics in electrical engineering than in either one of the disciplines independently. I'm not sure that's really true, but that's the way I perceived it at the time.

Spicer: Did you have an inkling that you would be going into science versus art, or a fusion of the two?

Smith: Yes, no, I was pretty sure I'd go into science. I was also a clarinet player, and I had thought about music a little bit. But I knew I wasn't really good enough, whatever that meant. And I suspected the same was true of art. And science I was a natural at, and I was getting rewarded highly by it. So it really was no question. But the surprising thing that happened was while I was at undergraduate college at New Mexico State University in Las Cruces, a fellow came in from White Sands Missile Range and taught us a class on this new thing called "programming." And another good thing was, it wasn't FORTRAN. He taught us ALGOL, which is a beautiful language; as opposed to FORTRAN, which stinks.

Spicer: Yes, you and Ed Catmull have an antipathy to FORTRAN.

Smith: Oh, we do! Yes! It's one of the ways that we first related was we found out that one another despised FORTRAN, even though both of us knew it very well, had taught it. This is kind of leaping ahead, but when we started the New York Institute of Technology Computer Lab, we didn't allow a high-level language, because that would be FORTRAN, and we did not want to do FORTRAN. We knew there had to be a better language out there. So we decided we would program in assembly code- which is torture, as everybody knows—until this high level language came along. And then one day—so we did that for several months, maybe even a year—and then finally one day a guy from Toronto showed up and he told us about this new system called UNIX, and it had a language called C, and we went, "The letter C?" He says, "Yes, the letter C." You know, we saw that, and "POW!" We knew that was it. We went for it. Early adopters.

Spicer: Yes, you were using DEC machines at that time?

Smith: That's right! One of our lessons in life was if you treat college students well, they'll remember your company the rest of their life, and DEC had treated us very well as students, and IBM hadn't. So when we got a chance to buy our machines, we bought DEC machines. We ended up buy the first VAX. The very first one. The very first one was supposed to go Gordon Bell's CMU alma mater. And actually what happened was the Serial Number 1, which was supposed to go to CMU was behind Serial Number 2, which was supposed to go to us. So they made them both Serial Number 1, gave us ours first, and it was a cute little story.

Spicer: Now there's a story that you rescued a VAX from catastrophe.

Smith: Gosh, you know this stuff!

Spicer: Can you tell us a bit about that?

Smith: Yes, this VAX, the very first one was being delivered. It was a big deal, it cost a lot of money to the computer lab at New York Tech, we called it. And I was going out the door one morning of the computer lab, just as the new VAX was being offloaded from the back of the DEC truck, you know, onto one of those ramps. And onto the similar ramp of a New York Tech local small truck. As I opened the door, I saw that the New York Tech truck, with nobody in it, was slowly moving away, with this computer balanced between the two ramps. And so, <laughs> luckily the door was opened, and I just one of those "you do the right thing/wonder how you knew" I ran with everything I had and leapt into the cab of the truck with foot on the brake and the clutch at the same time to stop the thing.

Spicer: You saved the day!

Smith: Saved the VAX. And you think, "How long would it have taken us to get another one?"

Spicer: That's a good story. So you're involved in all aspects of the Computer Center there. Just skipping back a little bit, you were also a professor of engineering, electrical engineering.

Smith: Yes. I got my PhD at Stanford, and got my first job at NYU as a EE [Electrical Engineering] prof. [professor] But the chairman made it clear that my job at NYU was to get the department name changed from EE, to EECS. It took us four years to do it, but we did it. And I had to combat the EE professors who would say, "Well, after you've learned FORTRAN, what else is there?" I was, "Oh, man! This is going to be hard." That was one of those things I thought was impossible, but we actually pulled it off. At Stanford, I had been in computer science, even though officially I was in the EE department, because my fellowship was paid by them. I took all my classes in this computer science school, I didn't even know existed when I went there. And got my degree in a computer science topic, and they think of me as their student now at the Computer Science Department in Stanford.

Spicer: Now you studied Cellular Automata, which is a fairly erudite area of mathematics.

Smith: Cellular Automata is a mathematical formalism of a highly parallel computer, one might say. But the thesis was mathematics. It was definition, theorem, proof, definition, theorem, proof. Just straight through for a couple hundred pages or whatever it was.

Spicer: So not light reading. And this goes, that field itself goes back to von Neumann and Ulam and those kinds of guys?

Smith: That's right. And I learned about it from Martin Gardner, who just died last week. Martin Gardener. You know, I grew up in this little town of New Mexico, had a public library, and I'd go in there, and I'd just go with this magazine called *Scientific American.* And it had this column, Martin Gardner's column, where I learned stuff I still love, topology and games and stuff. And I was living in New York as professor at NYU, when I got my subs—you know, the subscription came in, the magazine came for that month. And Martin's column was about "The Game of Life." And I looked at "The Game of Life," and I said, "This is Cellular Automata theory! I just my wrote my thesis on this. And it's clear to me that Martin doesn't really know all that." So I called up Martin Gardner. Which I wanted to do anyhow. He's a hero of

mine, right? And I said, I told him, I say, “You know, this is a topic that von Neumann and Ulam were involved in, and there’s a theory of self-reproducing machines that comes out of it. And it’s a very elaborate—it’s not just a game, it’s a whole elaborate theory.”

And he came down to visit me the next week from Croton-on-Hudson, I think is where he lived. And I was a very hirsute, you know, hippie-like, but still professor. And all the students on the campus are covered with hair, too, right? It was that time. And the first thing that astonished me was Martin Gardner seemed to be surprised by the hair. And he was talking about all the hair. He was saying it like, “Where is this guy?”

And finally I figured out—oh, part of that story was *de rigueur* underground reading in the fabulous ’60s in the Bay area was *The Annotated Alice,* by Martin Gardner. He didn’t seem to know that. That it was the drug culture that had made his book so popular. You know, that’s why I was surprised that he was sort of surprised by all the hair. I said, “Gee, we’re his people! Doesn’t he know it?” <laughs>

And but he spent the day with me, just walking around, he kept apologizing, “You know, I’m not a mathematician. I’m a philosopher.” Baloney. The guy remembered everything I said without taking notes, including proofs of theorems, and the story was that the article on “The Game of Life,” had been the most popular that *Scientific American* had every published, and they wanted to do a cover story issue. So he was writing another column, where he wanted to flesh it out with all that stuff that I’d told him about. And that’s what the next column was. And to me, the big important part was I got to do the cover.

Spicer: Oh!

Smith: Martin called up and he says, “You know, this is the hot issue. This is going to be the—but we need a cover design. He says, “I’m going to submit several designs; one of them is based on Ulam’s work in early Cellular Automata theory. Why don’t you submit some designs?” So I had just proved a theorem and presented it at conference, probably Foundations of Computer Science Conference, or one of those. And it was about palindrome recognition by Cellular Automata. So I color-coded up the palindrome “too hot to hoot” that I’d learned from the *New York Times* crossword puzzle, and showed—just did a space/time diagram, but it was all, you know, graphically in color, graphically displayed, and colorful [ph?], you didn’t have to know what it was to kind of appreciate it. It was a nice cover. And mine got selected, because the publisher of *Scientific American* turned out to be a palindrome freak.

Spicer: Oh, wow!

Smith: <laughs> And then I got my first taste of fame, because I just started hearing from people all over the world about this article and this subject of life, and Cellular Automata and my cover. It’s the first time I realized, “Oh, there’s a huge world out here that’s paying attention if you’re in the right place. <laughs>

Spicer: That’s great. So what made you leave the university for Xerox PARC?

Smith: I broke my leg. I broke my leg skiing. I wasn't ever a very good skier, but I was enthusiastic, and I was up in New Hampshire, and classic thing, end of the day, when I was too tired, I did one more run. And my hat came down over my eyes, and I was blinded right at an ice patch. And when I got the hat back up. I got it up just in time to see this guy out of control coming by me, and there was no way to stop. And I went right through him. He walked away, but I had a broken femur. So I was laid up in a cast for three months.

Spicer: And this cast was a full-body cast, right?

Smith: Cast was a full-body cast from my ankles to my nipples, completely helpless. You find out who your real friends are. And there's nothing to do but just think for three months. And I discovered that the mind is vast when freed up of worrying about moving itself around, moving this body around. There's all this leftover thought space. It's vast! And it's fun! <laughs> Everybody said, "Isn't it horrible?" I go, "No! I'm having the best time of my life in here!" You know, the days are infinitely long, and I read books, I have conversations, and I just rethink everything! I'm having a ball!" And one of the things that came out of it was, "Alvy, you're not taking care of your art. You know, you've got a job," and it was also Vietnam War time, right? And I felt like I was feeding the machine with my students, and I didn't like that aspect of it. And I decided that when I got out of the cast, I was just going to dropout of academia and go to California, where something good was going to happen. And I still am astonished that slim of—totally impetuous move, actually, I actually changed my life, and it worked.

Spicer: So you had nothing specific to go to.

Smith: Nothing, no, no. The piece of luck was I had met a guy in the last days of academia at NYU [New York University] named Dick Shoup. And Dick Shoup had just got his PhD from CMU on highly parallel—he sort of had the hardware equivalent of Cellular Automata. You know, he actually built real machines that were modular. And I was asked to put together a panel on highly parallel computing for some national computer conference in Boston, and I went out looking for good speakers, and I found this guy, Dick Shoup. Everybody says, "Oh, you got to talk to Dick Shoup." And we hit it off. We really hit it off. We're still best friends. He lives down San Jose. We're still best friends.

He went off to do something in California, and I went off to break my leg skiing, and what happened was when I came out to California, I didn't come out to see Dick, but that's what happened. I got out here. I was living in Berkeley. Just bumming around in Berkeley. I taught a class in Cellular Automata at UC, just to pay the bills. And then I ran out of money. So I was asked to write the introduction to the German edition of von Neumann's *Theories of Self-Reproducing Machines*. And so I decided to make this introduction my swan song in Cellular Automata theory. Just write anything I knew. A complete survey of the field with full literature. So I wrote it, but I didn't have the references. But I knew Stanford's library, the CS Library at Stanford had all the references, so I called up my buddy, Dick, that I knew lived over here somewhere in Palo Alto, and I said, "Can I come over and bum a room off of you, so I can go the library, the CS Library at Stanford?" So that all happened. Got my references. Spent the night with Dick, and he said, "Well, why don't you come over and see what I'm doing at this place called Xerox Palo Alto Research Center. And I went, "Oh, okay." And you know, I felt obligated. I said, "I can only spend a short time. I got to get back." Don't know what I was getting back to, but I had to get back. <laughs> Well, I walked into his lab at Xerox PARC, and he was building the first Paint program, and of course, that's

exactly—I looked at it, and I knew this was it! This was art and science, computer science, in particular combined. This was what I had come to do, right? And I was staggered. And so that changed everything. Dick got me, not hired, but employed at Xerox PARC. They didn't have any slots. So he and Flagel, and Alan Kay, and some other buddies, you know, picked that liked me, hired me with a purchase order. <laughs> Which I still have.

Spicer: <laughs> Oh, that's great.

Smith: The purchase order, and when they unloaded me several months later, they canceled my purchase order. That's how. So I've got the PO and the canceled PO both. Sort of proud of those.

Spicer: The system that he showed to you was SuperPaint?

Smith: It was Super Paint, Yes, an early version of SuperPaint.

Spicer: Okay.

Smith: He built the hardware and the software. And Dick's really special in my life. I said, so basically what I got purchased to do was to show off his machine as an artist. That's what he wanted. So I would paint pictures on it, and do videos, and some of the first animations, cell animations. And I had to learn how to record on video. I didn't know anything about video recording really. And I had to—I learned from this guy, Jim Mayer, who was the Xerox PARC video whiz. And I'd sit around all night long and just make art, and record, and edit, and just—I was in heaven! Just in heaven. Couldn't believe it.

Spicer: Did you have any people working, artists, in the same area? Or does no one at the time...?

Smith: No, there was nothing else.

Spicer: No one had access to the equipment.

Smith: No, this was the first, the beginnings of raster art graphics. But the other artists that I knew about where—there was Tom [Thomas A.] DeFanti and Dan [Daniel J.] Sandin at Chicago—I think it was University of Illinois, Chicago Circle, who did vector graphics art. We used to have these big battles about who is the real artist, right? They claim, "Well, we do real time. Whereas, you pixel guys," you know, I made the distinction between pixel-based computer graphics, and geometry-based. That's what we're talking about. Geometry is always a lot easier. So in those days, you could draw lines in real time, and do vector graphics in real time, and so they could improvise it. To them, being able to improvise was the art form. David de Francisco, who was my artistic buddy at Xerox PARC, and I were doing slow, tedious, had-to-be-edited, raster graphics. But we knew that it was just a matter of Moore's Law that this is going to get faster, and we would be in real time sooner or later, so this was just laying the groundwork. And that our world is much, much, much richer than their world. It would happen. You just had to have the faith.

Spicer: Now you mentioned the difference between raster and geometric approaches. And we spoke a bit about that off-camera, but would you mind telling us?

Smith: Yes, I'd like to tell you, because I think a lot of people don't really understand that there are really two ways of making pictures with computers. One of them is the pixel-based way, where it's based on sampling theory. The sampling theorem is one of the most profound theorems in our universe. It's how my business works. It's how digital audio works. It's how HDTV works. It's the fundamental theorem that drives the universe these days. So Photoshop is a good example of a product that exploits pixel-based graphics. It has nothing to do with geometry. The other way of making pictures is geometry. You define things in terms of lines and triangles and polygons and spheres and cylinders and patches and so forth. Which is what most—the term these days tends to be CGI, Computer Generated Imagery. What that really means is geometry-based. All of Pixar's movies are geometry-based.

Now what's confusing, why the worlds get confused is in these modern times, everything has to be reduced to a raster or pixels in order to be displayed on a screen, or put onto a film frame. So all this abstract geometry from say, the Pixar abstract geometry worlds, have to be rendered, is the term, from geometry into a raster pixel that get written onto the final frame. But in the geometry world, that's just the post-process. All the hard work's been done in this abstract geometric space. Now, I make this point, because those two worlds, the sampling theory-based way, and the geometry-based way grew up together. They've been around—I think the sampling-based theory was actually there first.

Spicer: With Nyquist and those guys?

Smith: Those guys, yes. But in terms of computer graphics, I've tried to find out, where was the first graphic done? And I've chased it back to the early '50s on a Williams Tube. I think you have one here in the Museum.

Spicer: Really?.

Smith: Well, Williams Tube, somebody apparently animated a glass of wine pouring out on a _____. It was a very crude...

Spicer: Using the bit pattern.

Smith: It's a raster, right? It's not geometry. And I haven't been able to nail exactly where or when. I haven't seen pictures. But some old engineer that I went to China with told me about this. And he had been there and seen it.

Spicer: Wow.

Smith: That's the earliest I've been able—point is, almost from the beginning of computers there have been artists. And there have been at least raster-based. Or not raster. I don't want to say that. I want to

say sampling theory-based, pixels. Pixels aren't little squares, by the way. That's another important message. They're points. Point samples. And shortly after that the geometry started coming along, too. If you look at all the early proceedings of the Care and Computer Graphics papers from the '60s, AFIPS conferences and things like that, there'll be articles about both. They were sort of in parallel worlds. There'll be—it's mostly satellite imagery that was happening then. This is where the sampling-based, the image processing world was getting its start. Interactive, too, I might add. And then somewhere in there, you get the first computer there. You'll get Ivan Southerland's paper and stuff like that, which is the geometry side of things. And when I was first going to SIGGRAPHs, there was always a parallel conference with it. There was SIGGRAPH in one room, and then in the next room, it'd be the image processing guys. So geometry in one room. Sampling theory in the next room.

Spicer: Interesting.

Smith: Everybody knew they had to go together somehow, but it was not well-defined. In fact, I think one of my own personal contributions is a strict definition of that boundary. And to even make it more confusing in modern movies, like Pixar movies, the two worlds are completely mixed up together, because all texture-mapping, which adds a lot of the interesting quality of the image to the geometry comes from sampled images that are mapped onto the geometric surfaces. So parallel histories. Two different basic theories behind it. Separate heroes. And frankly, a lot of confusion even amongst my peers, about when you're in one world, and when you're in the other. That's why I think of what I did was just sometimes say, "Look, here's the definition; here's how we get between the two worlds." There was a lot of ad hoc-ism going on at first that just turned into a mess.

Spicer: I guess that's typical in new fields. The nomenclature has to get worked out.

Smith: Yes, you got to find the boundaries and define them. And then you can do things with them.

Spicer: So how long were you at PARC?

Smith: I don't think it was even a year. I mean, physically, I was there a year, because I would hang out there before I got the PO. But once I discovered the place, I was there. Officially I was there, I think less than a year.

Spicer: Okay.

Smith: Of course, it was the heyday at PARC.

Spicer: Yes!

Smith: The personal computer, as we now know it, was being invented all around me! The Alto, and the UI, the Windows-based UI, and the mouse, of course. And [Gary] Starkweather was doing laser scanners. And Ethernet guys were doing Ethernet.

Spicer: Yes, it was all happening.

Smith: It was all happening! Everything we now take for granted was happening right then! Color graphics in my case, and in Dick Shoup's case, we were doing color graphics.

Spicer: You mentioned in an earlier talk that Xerox decided they didn't want to do color. Can you tell us about that?

Smith: So one day my boss—I don't want to use his name—called me and said, "We're going to let you go." And I said, "Well, why?" And he said, "Well, we've decided this is just not the future." And we said, "Well, color graphics is the future, and you own it completely. You absolutely own it! Lock, stock and barrel, nobody else in the world is doing it!" He said, "Well, I understand that, but we've decided, corporate decision is to go black-and-white." "Okay." <laughs>

Spicer: Great moments in business history. <laughs> And that's happened more than a few times at Xerox.

Smith: Now, just to be fair. I've been on the other side of that desk in my career, where I'm the boss, and the young Turks in there saying, "Oh, we got to do such-and-such." And I've probably made equally foolish decisions. But you know, you get presented many more possibilities than you can possibly implement as a corporation. You just can't do it. So you have to decide what it is that is your business, and do that. You can sort of see that Xerox, "We're in the black-and-white business. We do copiers, and we do—you know, that's what we're going to do. We're really good at it, that's what we're going to do." On the other hand, I, and all the other researchers at Xerox PARC cried. I mean, some of them actually sobbed big fat tears. They knew… they didn't want to let Bill Gates and Steve Jobs in the door. They knew what was going to happen. And it did! <laughs>

Spicer: Wow, so they were afraid that, even then, that someone would take the ideas.

Smith: Oh, they knew. If someone walks in here, they'll take it. It's once you the have idea, it's not that hard, you just go do it!

Spicer: That's right!

Smith: And that's exactly what happened.

Spicer: So you were sort of the artist-in-residence.

Smith: Yes, I was the artist in residence at Xerox. And I put together a reel of it.

Spicer: Portfolio kind of thing?

Smith: Yes, it was a three-quarter inch, terrible U-Matic thing, but I took that with me to New York, 'cause that's where I went next.

Spicer: Yes.

Smith: And used it to get my way into the video art world. It was this new exploding artistic world in New York City. You know, I came in with this, and I said, "You guys have never seen anything like this." And they threw on the disk, and went, "No!" I mean, threw on the tape. "No! Can you show this?" I said, "Sure! Yes, Yes."

Spicer: Oh, that's great. So there's a story about your roommate and Alexander Schure were related in some way?

Smith: Okay, so you're talking about the—while I was working at Xerox PARC, I lived in Los Altos Hills—which is redundant. Always drives me nuts. I'm a new Mexican. It's like Rio Grande River, okay? <laughs> …with a really nice couple. And I brought Richard down. Of course, I was so excited about what was happening in the lab. You know, I also wanted them to understand why I never came home. I was going 90-miles-an-hour at PARC and would only go home to sleep when I had to. So they had seen what I was doing. And then Richard made a trip back East, where he came from. Back to New York, I think. And came back and said, "Hey! Alvy, my uncle's doing what you're doing." And I'm sitting there, "No, he's not," you know? "I know the whole world," right? Sort of this arrogance, "I know everything that's going on in this world. There's just a few places where anybody knows what we're doing, right? Or can talk about it." And he only saw what I did once. I mean, Richard had only seen. Okay, that's the background.

So, Xerox fires me. Cancels my PO. David de Francisco, who was an artist I had met in the City, San Francisco, and would come in and play on the machines with me at night at Xerox. And we had cast our lots together with the National Endowment of the Arts. And so we went together, first to Utah, to find out they wouldn't take a bunch of hippie freaky guys on there. Because they were Defense Department funded. But they told us about this crazy man out on Long Island, who had an animation house on his campus, and was going to make movies, and he was buying one of everything in sight at Evans and Sutherland. And we said, "Including the frame buffer?" The frame buffer was essentially the graphics card, which was the key machine that we needed to make our art. And they said, "Yes, he's going to get the next frame buffer once we build it." So we went out there fast as we could and saw this guy, got all excited. I came back and I was telling my roommates here, Los Altos Hills, I said, "Man, it's happening. This amazing man on Long I—" Richard stops me andsays, "Alvy, I've been trying to tell you. That's my uncle."

Spicer: Wow.

Smith: <laughs>

Spicer: <laughs> So he's right under your nose.

Smith: <laughs> Yes, so we called Alex Schure Uncle Alex the rest of our—long story short, we got ourselves there and I was working for Alex. And we called him Uncle Alex. We called him Alex to his face but Uncle Alex behind.

Spicer: That's great.

Smith: Isn't that amazing? I mean, I still can't believe that happened.

Spicer: Yes, that's an incredible coincidence.

Smith: <laughs> That's when you feel like okaaaay, <laughs>…

Spicer: <laughs>

Smith: …I guess I go here next <laughs>.

Spicer: Yes, it seems destined almost to happen.

Smith: <laughs>

Spicer: Well, tell us a bit about NYIT. What was it?

Smith: The New York Institute of Technology was a private university on Long Island, the fabulous North Shore of Long Island. It's actually four estates. This is The Great Gatsby part of Long Island, the fabulous estate lands on the North Shore. And Alexander Schure, Dr. Alexander Schure, put together somehow four of these adjoining estates, with their manor houses and so forth, as his campus, called the New York Institute of Technology. And it was a private university. Now it's turned in to be a pretty incredible place I think. But at the time, it was just a diploma mill. Just to be honest. And it was designed for kids who couldn't get into real colleges. They could live at home, with mom and dad, on Long Island, and drive in and get a degree that was—be typically something like video engineering technologist. So the first two words would be a recognizable profession and had the word technologist tacked on the end. And the, I mean, I thought the most representative thing was the bookstore, which sold auto parts.

Spicer: Wow <laughs>.

Smith: His window display was tires and batteries.

Spicer: <laughs>

Smith: <laughs> Now, again, just to be fair to the place, that was long time ago. And it's now got a downtown campus in New York City, and it's apparently quite respectable.

Spicer: It's a happening place.

Smith: Yes, it was pretty amazing at the time. Here it was. It was all estate manor houses <laughs>. The videos were in one manor house, and the graphics was in another manor house. And the buildings in this campus n—we had nothing to do with the campus, the school. Alexander Schure owned this place. By the way, he's about the only guy making money off universities at that particular time. He has us there in this—our computer graphics lab was just—it was completely separate from the university, except being on the grounds of the campus. He wanted to get rich making movies with computers. He had seen that that's the future, computers. Now, he just happened to be 20 years, 30 years too early. But he had the right idea. And he had brought—what got him there was he had aspired to be a Walt Disney. And he had an entire animation studio on the campus already of the classic cell animation variety. So he had brought these animators and background painters and editors and all mostly from Hollywood but also New York City. One of the early animators of Popeye was there, Max Fleicher's Popeye.

Spicer: Wow.

Smith: Johnny Gent was his name, little guy about this tall.

Spicer: <laughs>

Smith: Crazy collection. It was my first time encountering this crazy world of animators. Wonderful nutcases, just fabulous…

Spicer: <laughs>

Smith: …childlike. Then a salesman from Evans & Sutherland had just done a cold call on New York Tech and talked Alexander Schure into his future was to go with computers from Evans & Sutherland. And Alex bought in. He came out to Salt Lake City and met with Dave Evans and Ivan Sutherland. And they showed him all the stuff. And Ivan Sutherland kind of wanted to make movies anyhow. So he could talk some of the talk. Alex bought it. And, again, it's just one of those wonderful things. We found out from our friends at University of Utah that this man had done that, and we got out there as fast as we could. I spent literally the last money I had in the world to get out there, to check it out.

Spicer: To Utah?

Smith: To New York.

Spicer: New York, Yes.

Smith: <laughs> I'll ramble here a little bit. But we got there in the middle of an 18-inch snowstorm. It'd brought Manhattan to a halt. Had to get across this blizzard to get there. Nothing was going to stop us, right? We were going to go to this place. I'd asked people, at Utah, I said, "Well, do you know anybody there?" They said, "Well, we think, the kid that just graduated from here named Ed Catmull, we think he's there now." And he had been for about a month it turns out. So we get there. I walk into the door of the computer graphics lab and address the wrong guy as Ed Catmull. There are actually two guys there. I addressed Malcolm Blanchard as Ed. Ed had given up. He'd wanted to make movies with Ivan Sutherland using computers, but they'd given up. He had a family to support. And it just wasn't happening with Hollywood because of the economic downturn or whatever. So he had taken a job to support his family, Ed had, at Applicon, a CAD company, in Boston. And his officemate was another University of Utah person, Malcolm Blanchard. And then Alex Schure gave Ed a call, says, "You know, people tell me that, with all those machines, I need you to run it." And Ed, after only been at Applicon a month or two, did it. And he brought Malcolm with him to be a systems guy. So when David DiFrancesco and I show up on this blustery day, it's just the two of them there in this empty garage. My joke is, "We got started in a garage. It just happened to be a four-car garage."

Spicer: <laughs>

Smith: Because it was the garage of the Gary House. It was one of the mansions on one of the estates.

Spicer: Oh, yes, nice.

Smith: Okay. But it was empty. It had no machines yet. And I looked around, and <laughs> I talked to Ed for a while. I says, "You need help, don't you?"

Spicer: <laughs>

Smith: <laughs> I said, "You know, I've got a Ph.D. in computer science. And, you know, I'm here to make art, but I also need a job."

Spicer: <laughs>

Smith: <laughs> And that's how it happened, just that fast.

Spicer: That's great.

Smith: Went over and met Alex Schure. So we went to de Seversky Mansion, probably the grandest mansion of all on the New York Tech campus. It's had roles in several movies as the manor house. I think, Arthur, it's in there. Three Days of the Condor, it's in there. When you need a manor house, you rent the de Seversky Mansion. So I walked in, was led down into the basement, where this beautiful dining room was, with liveried waiters with towels over their arms and mirrors, those kind of gilt-laced mirrors, over all the walls.

Spicer: Wow.

Smith: One man, way in the back, he says, "Helloooo, California!"

Spicer: <laughs>

Smith: <laughs> That was the first contact with this amazing man…

Spicer: <laughs>

Smith: …this amazing man. And I showed him my video that I'd made at Xerox PARC. First of all, he couldn't find a working U-Matic deck. So he hauled us over to his mansion, where he lived with his wife. And he had a U-Matic in every room, but most of them didn't work.

Spicer: Wow.

Smith: And he had to move his killer dogs out of each room so we could get to the next room and try that U-Matic without the dogs seeing us. It was all nuts from the first few minutes even. But then I played it talking 90 miles an hour. It's hard to outtalk this guy, but I was so excited then I was outtalking him. And we were just <makes buzzing sound>.

Spicer: <laughs>

Smith: I was hired just like that <laughs>. And that's New York Tech. I mean, it's really—it's one of those things you just can't believe really happened. I'd get up every day. It's like I'm in a movie. I'm living on an estate. By the way, I lived <laughs> I told you where I worked. Where I lived was on a nearby estate, which turned out to be the family estate of the wife of David Rockefeller.

Spicer: Oh, wow.

Smith: It was called the McGrath Estate. This estate was called The Compound. And each member of the family had a house on The Compound, and we were the tenants. We lived in the chauffer's quarters.

People talked with a Long Island honk. You can tell which prep school they went to I understand from Tom Woolfe.

Spicer: <laughs>

Smith: Kid from New Mexico, what did I know, right?

Spicer: <laughs>

Smith: Except I knew it was amazing <laughs>.

Spicer: Some of this equipment that Alexander Schure bought, he wasn't quite sure what it was even.

Smith: No. He basically knew what the Picture System was, which was a early black and white vector graphics machine. But they somehow told him that this framebuffer, which is what you do raster graphics on, was to be purchased. And so he bought it. I mean, he really bought one of everything.

Spicer: How big were these frame buffers in capacity?

Smith: Oh, the frame buffer was about the size of two racks, so couple of refrigerators.

Spicer: But what capacity of memory?

Smith: Oh, well, it was a video frame buffer. So it held a display of video frame. So it was 512 by 512 by—now, here was the big deal. We bought a frame buffer, which was 8 bits deep. So call it 512 by 512 by 8 bits. You display 480 of those lines or 488, I think, of those lines to get the video out. Alex Shure. I'm going to try to tell you about this guy. He's hard to describe. He's unique. He would come in. We were up around the clock. Again, don't go to sleep unless you had to, because everything was new and exciting. And it was just there. The fruits were there to be plucked from the trees and picked up off the ground. Everything you touched was new. He would come by at unpredictable times, like 5:00 in the morning sometimes or 5:00 in the afternoon. He'd just show up. And he would always be talking, just talking kind of a stream-of-consciousness pattern. David called it 'word salad,' and I called it Casey Stengel speak. He would just talk, and you didn't know what you're supposed to do. You and I are exchanging sentences. Every so often we exchange a sentence and we acknowledge what the other said. That normal social game wasn't in play. It wasn't clear what you're supposed to do. So I'd start talking back. While he's talking, I'd start talking. That seemed to work. You'd somehow know that your idea had been incorporated into him. He had received your communication if you heard your words coming back in this stream of consciousness, this word salad. <laughs>

So, via this very elaborate process. We did a good information exchange. You also maintained the idea this guy was—he was out there on some planet. You didn't really know what. And one day he got—I'm

not going to try to tell you the actual words. But he basically asked what do we need to do to stay ahead. And I said, "Well, if you got two more of these frame buffers, two more of these 8-bit frame buffers, we could gang them together into what we call RGB, 24 bits per pixel. And then you can do full color." I had to explain all this, "You can do full color. You can do merging of colors. And you have so many colors it's, for all practical purpose, a continuum to a human viewer." So that got transferred I thought. And, oh, I think it was just maybe a month later. He walks in and says, "Oh, I got you two more—I got you five more of those frame buffers so that you have two RGBs."

Spicer: And these are big-ticket items.

Smith: Now, these are monster things, like a rack or two racks each. And they cost a lot, too. The first one, the first 8-bit one, cost 80,000 bucks in 1975 dollars.

Spicer: Wow.

Smith: And then the next five cost 60 grand each. I did the calculation once, where you do the inflation index and all that. It came out to be about a million bucks for an RGB frame buffer. He bought two of them and just said, "Here." Well, with that act, he put us on the screaming edge, because nobody in the world had full-color graphics, nobody. We did. And we just went hog wild and everything. I wrote the first 24-bit paint program first thing. I learned how to do paint programs from Dick Shoup. He'd done an 8-bit SuperPaint. So I merely wrote 24-bit paint, Paint3. Because you can do all this amazing stuff. It's soft colors and mixing and all that. That was my first—my first contribution was actually the HSV or HSB algorithm.

Spicer: I was just going to ask you that. You invented this new system of color.

Smith: Yes, well, you make it sound like it's a big invention. I'm an artist, and I had painted with oils and acrylics. When you mix paint, you take a hue and you de-saturate it with white paint or you darken it with black paint. There are a lot of variations on that, but that's roughly the idea. So I'm working with Dick Shoup's SuperPaint, where he had RGB controls. And I says, "Dick, how do I convert this? I want to use hue, add white and add black. How do you do that? What's the algorithm?" He says, "There isn't one." I went, "Oh."

Spicer: <laughs>

Smith: <laughs> And I went home that night and wrote it and came back and implemented it and added it to SuperPaint. That was my big contribution to SuperPaint was HSV. I mean, it wasn't a big deal. It's just nobody had done it yet.

Spicer: Can you explain what that lets you do?

Smith: Well, just what I said. I'm so familiar with RGB now that I can't quite remember what it was like to try to mix pink with RGB controls or brown. Well, with hue, saturation and value [HSV], it's really simple. You pick, for pink say, you pick red and you lighten it with white. You've got pink. What could be easier? If you want brown, you take red and you darken it with black, get brown.

Spicer: So what did this involve, setting different color values for the palette that you're working with?

Smith: Basically, instead of having three sliders on his menu, one for red, one for green, one for blue, where you could set the amounts of those three electron gun voltages basically, you would set the hue. In other words, you would go around the color circle, like you see in a paint store, and pick pure hue. And the saturation was equivalent to adding white. Fully saturated meant the full hue, and de-saturated meant white. So it'd be a pastel of your hue along that slider. And then the value axis was the adding black axis. Full value meant you were at the pure hue as de-saturated with white. At the other end was black.

Spicer: Makes sense.

Smith: All the tones of a hue were on this axis, and all the tints of the hue were on this axis. And then hue was on the top axis. It's just a natural—then I had to spend years telling people that it was just an approximation. It wasn't really hue, saturation and value the way human perceptual system does it, which is quite complex. It's just a simple transform of RGB, but it stuck. Obviously, it's still around.

Spicer: And is that what artists typically use now…

Smith: Yes…

Spicer: …that system?

Smith: …Yes. Well, Yes, there are two variations but same idea.

Spicer: You're both an engineer and an artist. Can you point out the relative roles of engineering/mathematics and art in developing these tools for artists? Would you have been able to make these contributions without, say, your engineering background?

Smith: Well, I think engineering is probably my main contribution. I like to think of myself as an artist, and I'm highly influenced by the artistic world. And I think one of my values in all this is I've been—I can talk to the artistic world. That's my world. But what I'm really good at personally is programming, math and science. I always wanted to think I'd be a great animator, but I know I'm not. I've been around great animators, and I know I'm not one of them. They are special talents of the first order on the planet. Nobody can understand. And, similarly, it was the same conclusion I got, too, on clarinet playing. I'm never going to be one of the greats. So don't waste time there <laughs>. You can let the people who are good at it do it. I'm good at the science side, the engineering side, the programming, understanding the

theory and all that. I think it's important that I did both, because I'm really comfortable with the animators and the artists. In fact, my first job at New York Tech was—nobody assigned jobs there by the way. We just did what we knew had to be done. If we're going to be an animation house, then you have to have a—you have to be able to paint backgrounds. And I already knew about painting. So let's write the background painting program. Well, there was an artist there, a real background artist, from Hollywood, named Paul Xander, X-a-n-d-e-r. Alexander Schure says, "I want you to work with Alvy, and we'll make this be what you need as a tool for animating animated movies." So I had an honest-to-god, real-world background artist as my first user. And it was amazing. This guy was technically un-savvy in every possible way. He also imbibed a lot. Basically, I had to make a program that could not break under …intense duress <laughs>.<laughs>…

Spicer: <laughs>

Smith: Anything that could be done wrong would be done wrong.

Spicer: <laughs>

Smith: Any way to destroy the image would happen. And it was a great discipline in the art of user interface, which I think is still one of the great art forms. It's still not very well done. Every day I complain about bad user interfaces. Paul, I had to get used to it, he would come in after eight hours working on a picture and say, <in a crying voice> "I erased all my…" I said, "No you didn't. I've got a backup."

Spicer: <laughs>

Smith: <laughs>

Spicer: That's good to assume the worst—

Smith: One time he came in. He says, "Ooh, I erased the backup, too!" I says, "That's all right. I have a second backup."

Spicer: <laughs>

Smith: <laughs> That was enough. He never went past two backups, though.

Spicer: You knew this guy well.

Smith: Yes, but you also learn what it meant to—any possible combination of things on a screen, you think somebody's not going to do it, they are going to do it. And it applies to all users of all apps I've discovered.

Spicer: So would you say that artistic gratification was kind of your main motivator rather than the technical part?

Smith: Oh, Yes, Yes, I would do the technical part not because I liked it but because I knew the tool needed to be built and I can do it. Let's do it, and then we can get to making art. I mean, I told you that David and I had—while we were still at Xerox PARC, we had submitted a proposal to the National Endowment for the Arts for a grant, especially for him, he had no job, to exploit this new artistic medium. We knew what it was. This is the future. And we got out to New York Tech. I got hired, but David still wasn't hired. He needed money. And we had this grant proposal already—in fact, the reason we were chasing the frame buffer is it required a frame buffer. That was what we're going to exploit with this proposal. So we got out there. And all of a sudden I hear David, who grew up in New Jersey, just berating somebody on the phone. It was somebody at the NEA, the National Endowment for the Arts. They had lost our submission. Now, at the NEA, you submit a one-page proposal and your work as opposed to the National Science Foundation, which I'd used before, where you submit a 60-page twenty-plicate…

Spicer: <laughs>

Smith: …proposal, right?

Spicer: Right.

Smith: This is a one-page proposal, and the work was what really mattered. The work was our videotape that we put together, and they'd lost it. So David just ripped them until they finally said, "Okay, okay. We'll give you a site visit." They didn't hardly ever give site visits, but they had done it. They knew they'd blown it, and they gave us a site visit. So one day, on Long Island, he and I, at the Manhasset train station, pick up Stan VanDerBeek, turned out to be one of my artistic heroes later, and Nancy Raines, I think her name was, from the NEA. It's like 4:00, and they said, "We need to be on the five o'clock back to Manhattan." We went, "Okay. We don't think you'll want to but okay."

Spicer: <laughs>

Smith: <laughs> Took them into the lab, and basically they were blown away. And we were there all night playing…

Spicer: Oh, wow.

Smith: …on this machine. About 4:00 in the morning, said, "Well, we really need to get back to the Algonquin." I says, "Oh, we'll drive you in." And we all jumped in the car and just kept jabbering on. We get in to drop them off at the front door of the Algonquin. I remember Stan reached his hand. He says, "You've got your grant, boys."

Spicer: <laughs> That's nice.

Smith: <laughs> It was art.

Spicer: <inaudible>.

Smith: That's making art. That was the thing. We were going to make art with this thing. That was our main motivating force. And I kept just throwing off the technical stuff on the side because I could. And I saw there was a hole there and I would do it.

Spicer: You told us about some of the specific techniques that came out of NYIT, the alpha channel, the RGB and HSV. Are there any others?

Smith: Well, the alpha channel, I didn't say much about that. I mean, it was basically another one of those things that's so simple.

Spicer: Why don't you tell us about that?

Smith: Ed Catmull, he had come up with a new hidden-surface algorithm, where he actually looked inside a—you divide a geometric scene up into little squares. Everything inside that little square becomes a single color at a single pixel. How do you decide what that color is? Basically, how do you decide the hidden-surface problem inside that little square area and map it onto a single color? So he'd come up with this algorithm, and he was testing it. And he was tediously rendering an object over a background into a frame buffer. He came to me. He says, "You know, this sure would be a lot easier if I didn't have to re-render the background every time. I've got this combining value that I combine the foreground image with the background image. Seems like, if we could just store that, then we could just, through a post-process, combine the foreground object with the background."

I says, "That's easy." I said, "That's trivial." I was sort of the master of save and restore, something else I'd learned from Dick Shoup, the save and restore routines for images and the file format that the images were stored in. I said, "That's really easy." I'd already extended the save and restore to three channels, RGB. So I had a one-channel version, a three-channel version. I says, "Snap. I can add a fourth channel." And I did it overnight. I added a fourth channel. I called it alpha. Because, the linear interpolation algorithm that we used, we state it as alpha A plus 1 minus alpha B, where A and B are the two images that you'd want to combine. And the alpha's the transparency value that you combine with. So alpha channel was the natural name for it, right? And I wrote up a UNIX-style manual page for it, this save and restore 4-channel version with this thing called alpha channel in it. That was it. Ed and I basically just did that overnight. Nothing to it.

Spicer: Wow.

Smith: Course, this is fundamental. Now you look back at it. Okay <laughs>.

Spicer: It's absolutely fundamental, Yes. And I think you've mentioned before how these giant frame buffers and systems are now on a graphics card.

Smith: Yes, now they cost nothing I assume. It's just sort of built into every computer you buy, iPhones even and cell phones that have the little color displays, right, which must be what we paid tens of thousands of dollars, probably million dollars in today's money, for then at video resolution, what was then called video resolution.

Spicer: Did you have any idea that we'd be making feature-length films with this technology?

Smith: Yes! Yes, that's what we wanted to do. We were hired to do that originally at New York Tech, right? We were not quite as foolish as, I maybe shouldn't say foolish, as Alex Schure. He thought any day that we're going to turn on the computers and he could fire. That's what he thought he was going to do is fire everybody, all the animators, and the computers would just do the movies. We said, "No, no, no, no. Don't even say words like that. We don't do the art. We can make the grunt part a lot better." But the whole idea was to make movies, and it always was. One of the blessings of my life was I was, one of my earliest jobs, was poured right into the middle of a animation studio, where I learned the full logistic path of animation, way—decades before we could actually do it. But when we would go to Disney, Ed and I would go to Disney every year thinking sooner or later they will do this, we could talk the talk. I mean, we knew it. We worked with these guys. We knew what the words were.

Spicer: Do you think there were any military groups working in the same area as you and coming up with things like the alpha channel and the HSV?

Smith: It could be. I mean, we never knew. And we still never heard that the military had done—I often thought—probably not anything that has to do with artistic aspects. Clearly those guys were doing serious image processing. But did they go to interactive? I don't know. Did they go to color? I don't know. I mean, I've just never heard. You'd think sooner or later somebody would've published a history of that from inside, but I've never seen such. Would be surprised if somebody hadn't done something though.

Spicer: Can you tell us about Paint…

Smith: Paint?

Spicer: …the program Paint?

Smith: I told you I learned SuperPaint from Shoup. I didn't just learn how to use it. Since I was a coder myself, I actually changed the code inside and would experiment with different tools and added HSV, in particular, to SuperPaint. So, in other words, I learned how Dick Shoup wrote paint programs <laughs>.

Spicer: <laughs>

Smith: And it was a great learning. And so first thing I did, at New York Tech, as soon as we got a frame buffer, was write a paint program, an 8 bit. Then we had RGB, and I wrote a RGB paint program. And then I branched that out. So that's what Paint was. It was an interactive sampling theory-based generator of computer graphics. This was your main tool, would you say?

Smith: That was my main tool to begin with, Yes.

Spicer: What other ones came along?

Smith: Well, every guy at New York Tech was generating their stuff as fast as they could. Ed was going geometric rendering. Basically, that's the hidden surface algorithms I was telling you about. He was trying to solve that problem better and better. David DeFrancisco, who was the artist that went with me out there eventually did get hired and he was mastering how you get images onto actual film frames. Garland Stern was doing—we bought a digitizer, you know, a real-time digitizer and he was learning how to digitize. The idea is one still used at Disney. The artist draws a frame and you scan it in, you clean it up digitally, you add the colors, basically it's all digital once the original artist does his drawings so we had to have all those steps implemented in order to have an animation system so we were working on all of that. I did a fill program where you just choose a color, choose an area, it would fill up with that color. It was the equivalent of opaquing in the old cell animation business. I made that thing go really fast, all in machine code or all assembly code, you know, where you pull out- pulling out cycles was a lot of fun. It's hard to believe we spent months doing that, you know? But boy did it go fast.

Spicer: How did you end up making [the film] Sunstone? Tell us a bit about that.

Smith: So, you know, at New York Tech, in the lab, I had brought my stereo system in and we lived there. We made the place as nice as we could, hung posters on the wall and it was just dark lighting. We were always showing it off to any visitors who came by. We had a TV set there, too. We didn't watch it much but occasionally we would turn it on. We were watching, you know, a public television station and they did a special on this guy, Ed Emshwiller. Turns out he lived right there on Long Island in Levittown and one of my colleagues said, "We ought to call him up and invite him over." I says, "You know, I don't think we'll have to. If he's the guy I think he is, he's going to find his way here."

And that's what happened. Sure enough, within about a month, there's Emshwiller in the lab. He says, "I've got this Guggenheim and I'd like to make a movie with you guys." And he says, "Oh, well, what do you have in mind?" He says, "Oh, hour and a half," and we all burst out laughing. He's got his dignity and he was rather affronted and said, "What's funny?" and we said, "Well, you'd be lucky, in six months," which was his sort of timeframe, "to turn out a minute and a half. I mean, this is really hard stuff. The machines are really slow." Basically, Sunstone, I think, was three or four minutes but he padded it with digitized live video and got it out there.

Anyhow, Ed did show up and this is where my love of artists and hanging out with them came to play. You know, I could talk art and he could talk science and we both appreciated the other side and we would just sit down. He would have an idea and he'd say, "Well, I'd like to do such and such" and I went, "Oh, we can't do that but if you change your idea a little bit like this, then I can implement it for you." He'd say,

"Well, if you can do that, can you do this?" We'd go back and forth and then we'd get someplace. I'd implement it and we'd record a little piece of video and then we'd go to the next thing. Sunstone came out of that process. So he learned a lot, I learned a lot, we really had a ball with each other. We just talked about everything, you know? Life, babies, should I have them or not, women, physics. He was a real physics buff. Cameras, video, you name it, the guy had been, you know, he'd done everything. He had been an abstract oil painter back in his youth in Paris and he had discovered 16 mm filmmaking when it was *the* art form and made 16 mm movies. Then he discovered video and made video movies and then he discovered video disc and did Skate Mates or something like this based on this video disc technology and now he's doing computer graphics and he'd done book covers, the '50s book covers and he was just a fascinating guy.

People thought we were father and son because he was a gray-haired version of- you know, I had real long hair, he had real long hair. His was gray and mine was black. We did that piece together. I'm still extremely proud of it. His daughter contacted me just last week. They're doing a retrospective for Emsh in southern California somewhere, San Diego, I think, and she had discovered the file that he had kept of the things that happened during that time. She said, "He had such a ball with you during that time." I said, "Well, you don't have to tell me, I know, but it's nice to know he wrote it down." <laughter>

Spicer: It is nice. Let's wrap up NYIT and talk about co-founding Lucasfilm's computer division.

Smith: Yes, well, so, even though New York Tech was a fabulous place, it was a fairy tale. Every day was a movie. We were living in mansions and so forth. Just, you know, non-stop visitors of all wonderful kinds. We discovered it wasn't going anywhere. We discovered that because Alex was making a movie called…, the classic way, called "Tubby the Tuba" and we all went downtown to the MGM screening room to see the rough cut or premier or whatever it was. It was awful. It had everything wrong with an animated movie that can be wrong. It had dust on the frames, it had drop shadows under the ink lines, the story wasn't good, the music wasn't good. It was just embarrassing. We kind of all looked at each other. Well, one of the young animators came, one of the few animators who had befriended us who was a young man says, "You know, I've just wasted two years of my life." He went off to work with Ralph Bakshi. We realized we've got the wrong guy. Shortly after that, there was a call to—I should tell one more story in here before I get to that.

Spicer: Yes. Sure.

Smith: Jim Clark was working with us. We had brought Jim Clark in, I should say Ed had brought him in, they were old buddies from Utah, to do what we would now call virtual reality, you know, headmounted display and add that. Jim and Alex just despised each other on site. It was like two bulls pawing the ground. To make a long story short, basically Alex Schure fired Jim Clark. We all thought very unfairly. There was not a reason for it other than he just sensed that here was a guy, an entrepreneur and he didn't trust him. It was an ugly scene. But what Ed and I learned was you got to be careful around this guy. He could be litigious if not downright nasty.

So our natural instinct is to be collegiate and just talk about everything, you know? Well, that story backs up the next one, which was a phone call came in one day from Lucasfilm to Ralph Guggenheim, one of our new employees who had just been at CMU and had some to help us with filmmaking. I should also

say that Francis Coppola called me that same morning but the person who called me I didn't trust and so I just kissed that off immediately but it still strikes me. Isn't that amazing, the same day? The people that called me from Zoetrope did all coke out later so it was- I made the right decision. It wasn't Lucas himself, it was his real estate manager who called. So Ralph came into the room where Ed and I were talking and says, "I just got a call from Lucasfilm." We said, "Shut the door and be quiet," because we had learned from the Jim Clark thing, if there's anything that might shake the work, just keep it quiet because we didn't know what would go on.

George Lucas had decided to bring moviemaking out of the 1940s level of technology into the 1970s, I guess it was by then, right? He had sent out this guy, his real estate guy, to find the people to do that for him. By a long series of snoops, he found he way to New York Tech. I think how it happened was he went to Stanford, which didn't have any computer graphics, and said, you know, "We're looking for people to help out," and this Professor Raj Ready was visiting from CMU, an AI professor, Artificial Intelligence professor from CMU Carnegie Mellon was visiting and he said, "Well, we don't know about that but I had a student named Ralph Guggenheim and I think he went to work for a place that's doing that kind of stuff." So that's how the real estate man found his way to Ralph Guggenheim.

We said, "Ralph, don't say anything to anybody." This is the call we've been waiting for, frankly, this is it. We realized, you know, we couldn't take anything with us and we also thought we should probably, if this actually happened, we would have to launder ourselves. We'd go somewhere else and make it clear that we were making a clean break and this was not taking anything from the place and, you know, be really careful about possible litigation. But we were living in heaven, right? This place was heaven. We didn't want to go to a lesser place, even though it was Lucasfilm. So we said, "It's real important that you send somebody out but it's got to be confidential. Just have somebody come. We have visitors all the time, just come." So Richard Edlund, Academy Award Winning special effects guy from Lucasfilm shows up wearing a huge Star Wars belt buckle, just huge. <laughter> What saved us was everybody had been working so hard for a deadline for some commercial we were working on, they were blasted. They just didn't have their wits about them. People who would normally ask questions didn't ask questions. They saw it but they didn't click like they normally would. So this guy walks around for a whole day to see where we live and what we're doing and then I took him into New York City and he and I played around all night long in Manhattan, just had a ball. He had never been to New York before so it was a lot of fun. Long story short, Ed and I made a trip out there and that worked. Then Ed made another trip out there and that worked and our idea was basically we would all quit New York Tech, go to separate places, get Ed in at Lucasfilm and then, as soon as he could, he would pull us in. That was the plan and that's what happened. David and I went to JPL where Jim Blinn was doing Voyager flybys and we were very clear. We said, "This is what we're doing, you know? We were making sure we got a clean break with Alex Schure and we're just waiting for everything to settle down at Lucasfilm so we'll only be here a short time. That's okay?" "That's okay." So that's what happened.

Spicer: So you went to JPL to sanitize yourselves?

Smith: Yes, just to be sure that Alex understood that, you know, we don't have anything of yours, we're not ripping you off, we're just going to make a clean separation here. We went there. Well, Ed went right straight to Lucasfilm, Tom Duff went to Three Rivers Computer Corporation which existed at the time. Ralph still owed a year of employment to New York Tech, which he honored. I think that was the group.

We also didn't want to raid the place. There were those of us who were going to leave no matter what but we didn't want to raid it because that's what it would have looked like. We didn't. Yes.

So this all happened. Ed and I are sharing an office with Marshall Lucas above an antique shop in San Anselmo. Then we moved into an old laundromat on Tunstead. It was kind of fun, the early days. Somewhere in there, though, I discovered that, uh oh, once again, we've got a new patron but he doesn't get it, either. We thought we were being hired to make scenes in George's movies. No, turned out that wasn't what George hired us to do. He hired us to build these machines, a digital video editor, a digital audio editor and a digital film printer. Ed was in charge of the whole lab, I was in charge of the computer graphics aspects and then we had other guys in charge of the audio, that was Andy Moore and Ralph eventually became in charge of the video editing.

Kept waiting for the call, you know, "Come be in my next movie." Never happened. Meanwhile, I was putting together this great team from all over the country and all I'd have to do was say, "Would you like to join?" and they'd say yes because they all thought they were going to be in the movies, right? So I was just putting together this first world-class team of guys. I think it was all guys. At first, it was. George never said no so we assumed that was the right thing, right? Wasn't happening. I finally went into Ed, I says, "He doesn't get it, either, does he?" and Ed says, "No, he doesn't."

So The Empire Strikes Back comes out and it has no computer graphics in it. See, what fooled us was Star Wars I had computer graphics in it, one scene, black and white scene done by Larry Cuba, our buddy, Larry Cuba. It's a vector graphics scene. It's a run through for killing off the Death Star, you know, you had to fly down this valley and drop a bomb into the secret spot. It's a black and white movie shown to the pilots in the ready room or something like that. So we thought, okay, computer graphics, makes sense he's going to go the next step and—no. No.

So the lucky break there was that Paramount hired Industrial Light and Magic, the Lucasfilm special effects branch, to do the special effects on Star Trek II, the Wrath of Khan. They wanted to put some of this new-fangled computer graphics stuff in their movie and the guys at ILM, Industrial Light and Magic, said, "We don't do that but I think the guys next door," being us, "I think that's what they do." So they called me up and I came over and they told me what they wanted. They wanted this scene in the movie where it was going to be an aquarium. They wanted to show off this Genesis effect which is crucial to the story and basically it was something that turned dead things into live things instantaneously. They needed to show this so they could show Admiral Kirk how to do it, how it worked. So they had to come up with this idea of an aquarium with a rock floating in the water and moss growing on it. I said, "Do you guys have any idea what we can do with computer graphics?" They went, "No." I said, "I didn't think so." I said, "Well, let me think about it over night and I'll come back to you with some ideas about what we can actually do that'll satisfy your needs here." They went, "Okay." That's when I walked out of the room, you know, about this high off the ground because I had just been given the right to design a scene in a major motion picture. <laughter> It doesn't happen usually, right?

I was up all night drawing storyboards and basically I had—well, I said, "Look, I've got Loren Carpenter on fractals, I've got Bill Reeves on particle systems, I've got Tom Duff on craters and I had just come from JPL so I could use the Voyager fly-by concept and we could fire a missile and had some embryological concepts that kind of went away but I threw all that stuff into the mess and came up with about six boards

that I knew we could do. There was a lot of hand waving in there, too, I might add. Something would happen in here and... <laughter> They bought it so that's how we got the shot. So, when I put the team together, after we got the job, I said, "Okay, we got the big break, finally been asked to be in what will probably be a successful movie," and it was, of course. We had two shots but the big shot, the genesis demo shot, I said, "This is a 60-second shot and we're going to design it so that Paramount is completely pleased with it and it'll thrill the audience and it'll make sense as part of the narrative but what this really is, is a 60-second commercial to George Lucas so he'll know what the hell he's got here."

By that time, and I think back over this and I can't quite figure out how I knew but I had watched movies with George in his own screening room to know that, when he watches a movie, he does this almost impossible thing, he gloms onto the camera man and all the decisions that the camera man makes. So he's tracking the camera. He's always aware of where the camera is and when it changes, when it's trucking and all that stuff. He's just completely locked on. You should try it sometime. It's really hard to do. In fact, the director has failed if you can do it because you have not been sucked into the emotion, right? But George can do this and so I knew this about George. I said, "We're going to design a camera shot that'll blow his socks off. He'll know that no real camera could possibly do this and, by the way, it won't be a gratuitous computer graphics 101 whip your head off shot, it'll make narrative sense but he'll know." That's what we did. That's what the Genesis demo shot is. It's a very complex spinning, spiraling, tracking camera shot which, next time you watch it, you should try to follow the camera. I hope you can't. <laughter>

Spicer: That's great. That's certainly one of the most famous scenes in...

Smith: It was the big breakthrough, you know? It was the first use of computer graphics in a successful motion picture.

Spicer: Did the commercial work? Did he start using you more and more?

Smith: Well, the most important thing he did, I believe, was not only did he get the message—but—and after the premier, he stepped one foot into my office and said, "Great camera shot." He got it.

Spicer: Wow. Very nice.

Smith: Yes. And he's rather shy so he was out of there. He told his buddy, Steven Spielberg about us and Steven had us in his next movie, which was Young Sherlock Holmes. Then it started to unwind from there. Then, in George's next movie, Return of the Jedi, he had one shot that was computer graphics. So, yes, he worked us in. But, you know, it started to happen then. The word started to spread that this was a real technique.

Spicer: Was it just as fast to create something on the computer as it was using traditional methods or was it faster?

Smith: Oh, it was incomparable. We would do things you couldn't do.

Spicer: Besides that.

Smith: That's the whole thing.

Spicer: Yes.

Smith: I mean, if you can build a model, then that's probably what you should do. In fact, one of the funny things is George Lucas used to say, "Look, I don't really care about how fancy your technology is, I'm all about telling stories. If I can get 100 dancing girls holding up cards to do my scene, that's what I'm going to use," which is a little humorous now when you look at how absolutely over the hill he went for computer graphics, right? He just took it right out to the screaming edge. <laughter>

Spicer: How did the computer division at Lucasfilm become Pixar?

Smith: Well, let's see. George and Marcia got divorced and, as everybody knows, this is a community property state so half the fortune went away. I remember going into his office, you know, "George doesn't really get us, he never has." We had built some prototype machines by then and we knew how Silicon Valley works, you build a prototype, you fund it and turn it into product, right? That's how it works. He didn't know. You know, he got his prototype, that's all he cared about.

Spicer: Is this the Pixar image computer you're talking about?

Smith: Yes, the Pixar and also we had a video editing system and an audio editing system. We had an audio synthesizer and a video editor. These are the three big machines that we'd built, had prototypes for. They all were productize-able. He couldn't afford us any more. I went to Ed and I said, "You know, George has never really understood us. He believes we can't do animation, that only Disney can do that." That's something I should add. Another one of the very luckiest breaks in my career was running into this kid, John Lassiter. Ed and I would go to Disney every year, usually, secretly, to see if they were ready yet and, on one of these secret trips, we met John Lassiter, who was one of the first animators who just was not frightened of us. The older animators wouldn't hear us when we said, "We don't do art, you know, we just..." He knew. He and I really hit it off. He hauled me down into the archives. I was a real enthusiast for animation. I had studied Preston Blair how to books and I had seen everything. We went down in the archives and I think Ed was with us and he said, "What do you want to see?" I said, "Anything?" He says, "Yes, anything." I went, "Okay. How about the dancing hippos from Fantasia." He goes and looks up on a chart, a drawer, pulled out a folder, there's the original Preston Blair drawings of the dancing hippos and he does that animator flip on there, you know?

Spicer: Isn't that amazing?

Smith: And, you know, he and I start bonding right there. Then he said, "Now what?" I went, "How about the drunk elephant from Dumbo?" And so we did that.. iI's off hours but he was at Disney. He was working for Disney. A few months later, Ed and I did our daily business call and he was down in Long Beach at the Queen Mary for a conference and we were talking. He said, "Well, I saw John last year. Well, he's not at Disney any more." I said, "Ed, get off the phone right now and go hire him." He goes, "Oh, that's a good idea." So that's what happened. But we couldn't hire him as an animator because George didn't believe we could do animation. So we had to hire him as a user interface designer but the point is we had him. He was working, he was on staff at this time.

Spicer: That's good.

Smith: He and I were already working together on the Adventures of Andre and Wally B at Lucasfilm. Okay. So the seed of the animation was still alive and well in there, right? We had done these machines and I said, "Ed, he's going to fire us." Ed grew up Mormon and I grew up Southern Baptist so I could talk religious talk to him. I said, "You know, it'd be a sin if this group dispersed." He agreed. I said, "Let's start a company." He agreed again. We went across the street to Larkspur Landing and bought how to start a company books and a couple of naïve guys, you know, didn't have a business bone in our body. It was consistent with Lucasfilm. He needed to sell us off to make some money. I mean, he really didn't know what to do with us. He needed enough money to run Lucasfilm because he'd lost such a huge chunk. Basically a process went into place to sell off the different parts of the company.

That's where Pixar came from. We went through a whole bunch of funding possibilities. The one that got closest to happening, which I shudder at now that I think about it, was Ross Perot. Ross Perot, who was at General Motors at the time, you know, his company was called EDS, Electronic Data Systems, so the company was General Motors, GM/EDS. That division almost bought us. The idea was to bring us into the General Motors world where we'd do real rendering of real cars and revolutionize that world. It got really close. They were going to give us an amazing amount of money, a lot more than Ed and I thought we were worth. What do we know, right? <laughter> So it go so close that we were in a boardroom, around one of those giant oval board tables in the Phillips of the Netherlands Building on 42nd Street, Manhattan, way up high, and it was the most intense day of my life because the future was being decided. There were four parties at the table. There was the Lucasfilm and their attorneys, there was Ed and me and our attorneys, there was GM/EDS and their attorneys and Phillips of the Netherlands and their attorneys. It was going to be a joint deal.

My head was screaming from stress pain, you know? The kind that kills you. It was really- I was basically incapacitated with headache because the pieces were being shuffled around on the board and I remember one point where it log jammed, nothing was happening, and that's where our attorney, Gordie Davidson, down here in Palo Alto, he reached into his head and pulled out something. This is why I learned to appreciate great attorneys, you know? Right in this heat of battle where I was incapacitated, he reached in and pulled out a solution that let the log jam free up.

By the end of that day, everybody, about 20 people around this table, are shaking their heads, which, in the business world, as it usually runs, is a go. Done deal. Except this very day. Uptown, at the GM building, Ross Perot was telling the Board of Directors of General Motors they were all a bunch of fools for buying Hughes. The next morning, Wall Street Journal basically said, "It's all over between Ross

Perot and General Motors." Everybody knew our deal was out. <laughter> There'd been this guy, Steve Jobs, sniffing around but he'd come in with a lower number and Lucasfilm thought they were going to get about three times as much so they pushed him aside. Basically I called up Steve and said, "We think if you make your move, it might work." It did. So we got Steve to be our money man. So he's our venture capitalist, Ed and I ran the place and that's the beginnings of Pixar.

Spicer: Wow. What were your major projects at Pixar?

Smith: Well, the first project was to keep all 40 of us employed and we had gone through this calculation, Ed and I did, well, let's see, software won't pay for 40 people, this has to be hardware. You have to understand, we weren't hardware guys but, anyhow, we said, "Well, we have this Pixar image computer, let's turn it into a product." So that's what we did. We had to learn the whole manufacturing business and everything. Basically barely kept ourselves alive, all the time turning out little animated pieces, you know? We kept the animation core alive and well and then, finally, Disney said, "Let's make a movie. The time is right." That's when it happened.

I left out a really important step in there that has to do with Disney. Over all these years, Ed and I were making our pilgrimages down there, we had met a lot of people, technical people, who became our friends and allies over the years. The guys at the top didn't get it. Finally, Eisner and Wells came in and kicked out the old fuddy-duddies that were taking the company down. And within a month of their showing up, they were at our doorstep saying, "Let's digitize our cell animation process." I told you that's what we were doing at New York Tech a decade earlier. We knew how to do it. We'd done it with animators. We knew how the process worked. We knew. So they finally got it. They could save their animation business if they would just digitize the process, and we were the guys that knew how to do it. And so we did that. It's one of the unsung projects that cemented the Pixar-Disney relationship. Took me about 18 months to negotiate the thing. They're really tough negotiators. But we did it. We generated a product called CAPS, Computer Animation Production System, for Disney. They did the logistics part. We did the hardware-software part. And all the movies since Little Mermaid, all the traditional movies, cell-animation movies, had been done digitally, at Disney, on CAPS. It made them a fortune, and it bonded the two companies—both companies did better than the other expected, faster and cheaper and all those good things that sometimes happen. So that really was what weighted the companies together. So people later came to me, said, "Isn't it awful that Disney bought Pixar?" I says, "No. Just what took them so damn long?"

Spicer: <laughs>

Smith: They could've had us for free, and then they could've had us for 5 million. And then they could've had us for 50 million. Steve would've sold for 50 million for a bunch of years to anybody. They could've had us for 50 million. Then they paid 7.4 billion. It doesn't really…

Spicer: Wow.

Smith: …make much sense, but that's what happened.

Spicer: What did the Pixar Image Computer let you do? We have one in the collection here. So I'm curious.

Smith: The Pixar Image Computer was a supercomputer for sample-based image computing. Other words, it would—the general-purpose computers just weren't fast enough to do serious pixel-based operations on four-channel red, green, blue, alpha pictures. So we built a machine that was fast enough. Basically, it was a four—since you usually do the same thing to all four channels, we said, well, here's a place where parallelism actually works. I should back up and say Cray tried to sell us a supercomputer for years thinking that we could just parallel. We couldn't figure out how to parallelize our operation. But here, it's clear how to parallelize. You just do the same thing on red, green, blue and alpha, have a separate processor. So we just got a huge speedup by going parallel. Now, it was a bitch to program. And as soon as Sun's and Silicon Graphics' machines, general purpose, got fast enough, which wasn't very much later, just by Moore's law, then there's no reason to have Pixar Image Computers anymore. By the way, who was our number one customer? Disney. Disney bought every Pixar Image Computer they could get their hands on, because the system we built for them was designed around it. So Disney was the big customer. The other set of big customers were those three-, four- and five-letter agencies, where Mr. Brown picks up the product in a parking lot.

Spicer: <laughs> Okay. Why did you leave Pixar?

Smith: I left to start another company. Steve and I basically don't like each other, Steve Jobs and I. I want to be careful about that. He's been very important. He came through with the money when we needed it. And he and I personally don't get along, and it came to a head. There was never any pressure to leave, but I decided it'd be better for me psychologically if I got that guy out of my life. And so I, by another set of lucky coincidences, found an idea for a product, PC-based product. And with funding from Pixar, which means Steve because he was majority shareholder, I started a second company, Altamira Software, and sold it to Microsoft. So, in a sense, I sold my first company to Steve Jobs and my second company to Bill Gates.

Spicer: <laughs>

Smith: <laughs> And I'm a happy camper <laughs>.

Spicer: It's a pretty good track record. Over the course of your career, what would you say were the most lasting of your contributions?

Smith: Hm. Well, Pixar. You probably mean technically perhaps. But, to me, putting together the team now known as Pixar, starting on Long Island, in the '70s, was the big event of my life, the thing I'm most proud of. Yes, I'm proud of some of the algorithms I've donated. I'm proud of my Paint program. I'm proud of all the firsts. I'm really proud of the piece Sunstone with Ed Emshwiller. I mean, artistically that's my favorite thing I ever did. I'm extremely proud of my baby.

Spicer: I know that there's a lot of resistance amongst the older animators about this new technology.

Smith: Yes, they were afraid for their jobs. No matter what we'd say, they were sure—because that was sort of what was happening in industry. And we did take people's jobs away, but we took the grunts jobs away. We didn't take the artistic jobs away, and that's what we wanted to try to get across. Yes, some of you are threatened. There's no question about that. But none of the artis—

Spicer: What are the steps in the development of Pixar that would allow a movie like Toy Story to be made?

<crew talk>

Smith: Well, the basic idea of making a CGI movie is straightforward. The details, of course, are torture. The basic idea is you model a 3-D world in abstract geometry. You can think of it as describe with a language, but somehow you model the appearance of those geometric surfaces. So there's the shape information, and then there's the shade information. And you specify whether something is made of plastic or cloth or is it fuzzy or is it—what are its reflectance properties, is it transparent, all those things that have to do with the appearance of surfaces.

We invented this language called RenderMan to solve that problem. It turned out to be—in the early days, you'd just do one-off algorithms for each one of those ideas. And finally Rob Cook and others realized we can define a language that lets you describe arbitrarily-complex shading effects, shaders as we call them in RenderMan. That was a revolutionary step. So you build this world of characters and backgrounds. You put virtual cameras in that world. You animate the characters in that world as seen from virtual cameras. And then you take what those virtual cameras see, and you turn it into pixels on a film frame. That's called the rendering step, most complex step of all, to take all this information, all the shading and shaping information, and turning it into actual color pixels, an array of color pixels, that you write onto a film frame or put onto HDTV or some final delivery format.

Now, that's the basic—now, the full logistics process, which we learned from the early animators and really learned from interaction with Disney for the CAPS project, was set of animators start out with a story and a storyboard. This is still unchanged. I think some of the storyboarding's now done digitally, but I'd be surprised if it's all done digitally. It's just easy to whip out sketches if you're a good artist like these guys tend to be. You whip out storyboards just to get a idea of where the characters are, maybe what the camera shot will be and what the scenery might be. And you work it out, and you tack it to the walls. And you move things around till you actually get a story. Then you'd go through the modeling step, which is to turn all those characters into actual 3-D models and all those sets that they work in into 3-D models. And the guys in charge of lighting have to come up with where the lights are going to be and where the shadows are going to be and what the surface textures are and so forth. Very elaborate process, also the one where the technical people and the artistic people have to work hand in hand. Because they tend to be of different mentalities but they have to love each other and respect each other. That was one of Pixar's greatest accomplishments. It might go back to the fact that art and science, both worlds, were there from the top down so to speak.

The animation, of course, takes a long time. It's done usually interactively with—I guess they're still using SGI boxes. But I'm retired now. I don't know, but I imagine it's still done with SGI boxes or something equivalent, where, again, the technical person has to give the animator all the articulated controls that he

needs to, say, position an arm. And then the animators actually do the animation. That's where their expertise—that's one of those things that's hard to define. But they know how to put a slight nuance into a gesture that gives it meaning that an animator like me can't do, okay? And I've done animation. So I know that I can't do it. And then you render it. There's all kinds of checking steps, logistic tracking steps that are not fun to talk about but are crucial. And one of the things I think we mastered early on was the logistics.

We actually used to use these green sheets, these engineering pads, these green—slight green engineering pads, I think they still have them, they're divided up in grids, is that an engineering pad, no, I guess it's not, to do our logistics on. Then, course, we eventually got it all onto computer based. Again, one of those inglorious parts of it. But you have to master the logistics, and we did. We did that early on, mastered logistics.

Also another thing we did really well, it's not really about the process so much as how do you do it successfully, is you, and I've already alluded to it, you have to have the technical people and the artistic people admire and respect one another. I'm emphasizing that because I've been in so many places where it wasn't true. Either the artistic guys look down on the technical guys as being those droids or the technical guys look down on those artistic guys as those guys who aren't good enough to program, they only do silly stuff like make art. And I've been in both places. It's awful. It's corrosive. And it's everywhere. So I'm really proud that Pixar is way past that. Both sides know that they depend completely on the other kind of mentality. They're both equally creative. I object to people saying it's the creatives versus the technicals. That's a terrible use of words. They're both very creative. They have to work together. And sometimes I think the technically creative aren't given as much credit in Hollywood as the artistically creative and probably should get a little bit more. But Pixar did a bang-up job of that. I'm exceedingly proud of that part.

Spicer: The other question was the old versus new, Fortran versus C, color versus black and white and then this modern method of animation. You're always stepping into new worlds, where there's a little bit of resistance from going there, even with George Lucas. He was used to traditional film techniques, traditional 3-D animation. And he didn't quite know what to do. Do you just want to talk a little bit about that?

Smith: I'll try. I'm not sure what the question is. But let's start with George. George, to him animation was not—he made a distinction. And there was this big distinction, in the early days, between effects animation and character animation. Effects animation is flying logos, and character animation is where you have characters. It's much easier, in the early days especially, to do effects animation. And that's what George thought we were was effects animators that just did jobs for hire for the artistically-creative guys and animation, meaning character animation, was something that only Disney could do.

George actually said that, Disney was the only company that knew how to do it successfully. And he just couldn't see past that, that they were really the same. There really is no line there. I think there is a line there, actually <laughs>. Convincing somebody that a stack of polygons has consciousness and feelings and emotions is something really special. That's the essentials of character animation and what you can't really teach anybody. They just have to naturally have the talent for it, like John Lasseter and Brad Bird and so forth, Andrew Stanton, guys we had here, Yes. I'm not sure what distinction you're trying to make

between color and black and white. Color was always the future. Xerox PARC stuck in black and white because they thought that was their core, what's the term, their core excellence, their core whatever it is. I think maybe they were right. They're still alive, which is pretty good.

Spicer: They make color copiers now and color printers.

Smith: Yes, maybe they've made the right corporate decision for their own health. I don't know. There was no stopping color, though. I mean, that was—we knew that was where it was going. There's no resistance ever, except Xerox PARC <laughs>. And that might've just been pruning the trees so you can actually do something decision. Vector versus raster turned out t—which I would express as geometry based versus sampling based, is really not an issue. Once Moore's law gave us the horsepower, then the two essentially became the same. Games now are real-time raster graphics for all practical purposes. So you can see that that's become almost a nonissue. Still a little ways to go there. What was the other distinction?

Spicer: Just the resistance of the traditional animators.

Smith: All right. Well, that, I think, was a generational problem. The older animators had grown up in a world where computers, these new things called computers, were starting to take people's jobs away in industry. That was sort of the word, and it was true. It was happening. And, in fact, we were going to take people's jobs away, too. But what we tried—what we couldn't get across to the old animators, we weren't going to take their jobs away. We cannot do animation with a computer. Nobody knows how to do that. You can do some of the physical modeling, say, but you can't do this consciousness-creating kind of animation.

The grunt jobs we did take away. The reason CAPS worked so well for Disney was they were able to take, I don't remember the exact numbers, but a 300-person team down to a 150-person team to make a movie. Well, that made the difference between animation being kept alive at Disney and it being killed off. It was in threat of being killed off. Roy Disney came and says, "We will not kill off animation at Disney. We will go with these Pixar guys. They know how to do it." Lucasfilm guys at the time. And that's what happened.

And then the new generation came along. I mentioned two. One was Jamie Davis, who was the young man at New York Tech, who worked on Tubby the Tuba, befriended us. He was a little nervous about us, but he was willing to spend time with us and check out this new technology, went off to work for Outbackgee [ph?]. And second one, very important one, was John Lasseter, who got it. He tied his star to it obviously with great success.

I'd love to mention Brad Bird because he's one of my favorite animators. He talked about this, I think, at the computer museum talk. He came around early. He would come hang out with—while we're still, I think, at the Laundromat, in San Anselmo, he would come hang out. Maybe even while we're still in the antique shop. And he wanted to make movies using this technology, but he didn't have a technical bone in his body. And, in those days, if an artist wasn't willing to put up with the crap, the noisy air conditioners, the slow machines that broke if you looked at them, if you weren't willing to put up with that,

you just couldn't do it. Ed Emshwiller put up with it. My buddy, David DiFrancesco, put up with it. David N. [ph?] was another guy who put up with it. Early artists did put up with it, but Brad Bird was not ready to put up with it. So I was thrilled beyond belief when *Incredibles* came out. Because Brad Bird had finally, I'm sure he still can't do technology—was able to implement his story, which I think is one of the better Pixar movies if you want to distinguish. The technology had advanced so that a guy like him could implement. I'm really tickled about that. He's a funny man who needs to be seen <laughs>.

Spicer: Very passionate.

Smith: Yes.

<crew talk>

Smith: Do you want me to talk about anti-aliasing and motion blur?

Spicer: Yes.

Smith: So I've made a big deal how the sampling theorem is sort of the most important theorem of modern audio-visual anything. Basically, the idea is sampling theorem is, if you do it correctly, you can represent a infinite number of points, a continuous surface, for example a surface that you could see or a sound wave that you can hear. You can represent that continuum, that infinity, with a set of discrete samples. It doesn't seem like it could possibly make sense, but it does. If you put the samples at a certain frequency, high enough frequency, and you reconstruct them with the right-shaped filter, you can, theoretically, get back the continuum you started with. And that is the basis of digital video and digital audio.

The sampling process, there are lots of things that can go wrong with that process. And one of the ones that everybody understood early in computer graphics was you get jaggies. If you don't do correct re-sampling, you get stair steps along straight lines. The equivalent in time—a movie is a sample in time. You take 24 samples per second to make a movie or 30 samples per second to make a video. That has the same problem, only it's called jitter. The stair steps in time are called jitter. If you see an old Ray Harryhausen movie, from whenever, '60s or whenever he did his stop-motion animated movies, Clash of the Titans and stuff like that, it's interesting. It has this horrible jitter to it. And that was always what was wrong with early stop-motion animation was the jitter. It was what was going to kill us, in computer animation, if we didn't solve it. And we realized the way to solve it was some kind of blur through time. "Motion blur" we called it.

And one of our bigges—one of our—so we attacked that problem on all fronts. When Ed and I started Lucasfilm, we left New York Tech, come to Lucasfilm, we had learned that you cannot solve anti—anti-aliasing is the clumsy name for getting rid of the stair steps, okay? You can't anti-alias, you can't de-jaggy after the fact. You have to have that built in to the algorithm from the get-go. So we came up with this T-shirt design that we passed out ay SIGGRAPH which was the international don't sign with a stair step behind it. Don't jaggy <laughs>. Don't create jaggies. You weren't allowed to write code at

Lucasfilm if it didn't take care of jaggies. And we had RGB alpha at the time. So we understood that we had everything in place. So nobody had to write that jaggy code anymore. And it's what set us apart from our archrivals, which were John Whitney Junior and Gary Demos. They were the guys that we thought might beat us to the first film. The goal was to be the guys to make the first film, and these guys were good enough to do it.

They made a mistake. They bought a Cray, and they didn't make it. And they also didn't anti-alias. So we anti-aliased from the get-go, got rid of the jaggies early on spatially. But then we still had this problem of how do you do it temporally so you don't get the jitter when you animate. Remember, one of the hardest problems in computer graphics is, when you finally render a scene, you've got to figure out what surfaces are hidden by the front surfaces, not spend time rendering them. It's called a hidden-surface algorithm. People spent years [writing[technical papers about how you solve this problem. If you add to the problem the fact that the scene is moving, then it becomes a four-dimensional problem, a four-dimensional, hidden-surface problem, which theoretically is scary. That's the problem that had to be solved.

So the solution basically is to—I think everybody knows that, a film camera, the shutter's actually open for a short amount of time. It's that <makes zipping sound> that happens when you push the button. During that time, if, in the real world, if somebody moves, they smear across the film frame in the direction of their motion. So we knew that that's what we had to do. We had to come up with some algorithm that would smear animated objects in the direction of motion, and that means articulated objects which are moving in different directions, during a simulated open shutter time. And that's what we solved. We came up with this beautiful algorithm for doing it.

It's funny. Ed Catmull started a contest. We knew this problem needed to be solved. We had these really hot scientists, including himself, start a contest, he was one of the competitors, to solve this problem. Well, Ed lost. But <laughs> what won was … the algorithm that we came up with is so beautiful that I allowed a patent to be sought for it. I hated patents, because we had been fighting patents all my career. People that would get patents ten years after the fact and claim it was innovative when it was really trivial just to hound people out of business. I was so furious about patents. I wouldn't let anybody do an easy patent. It had to really, truly be, what's the term, not obvious to those practiced in the art…

Spicer: <laughs>

Smith: …okay? Really annoyed me when all these patents, which are obvious to people practicing the art, got issued because it wasn't obvious to the patent attorney, patent office. This algorithm was such, and Pixar basically went public on the money they earned from this patent. I won't go into details of how that algorithm works. But that is what solved the motion-blur problem, and it solved a lot of other problems at the same time. It was one beautiful solution that took care of everything, this universal sampling theorem artifact solver. Motion blur is key. Solving motion blur was key to the future of animation. If we hadn't done that, we never would've been able to pull it off, Yes. It had to be done efficiently, too. You couldn't solve a 4-D… sit down and slog through a 4-D, hidden-surface solution.

Spicer: Is this algorithm available in a commercial product?

Smith: It's RenderMan.

Spicer: Oh, RenderMan.

Smith: Yes, Yes…

Spicer: Okay.

Smith: …Yes. And it's been written up. So it's basically a random—a variation on Monte Carlo is what it is. It's a beauty <laughs>.

Spicer: <laughs>

Smith: It's one of those where you don't mind losing the contest because somebody comes up with it <laughs>.

END OF INTERVIEW

