

Stanford CA
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Bernie Roth

An interview conducted by
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with
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Bernie Roth: I'm Bernie Roth, and I was born in the Bronx, New York City, and I grew up there. I went to school there and stayed there until after I finished my PhD. Do you want me to go back into the details of schools there?

Q: Yeah. Whatever you can.

Bernie Roth: Sure. I went to high school in New York, and I started a high school called Stuyvesant High School. And then I, at one point, transferred to a local high school called Christopher Columbus High School, where I graduated from. After that I went to City College in New York, and I studied mechanical engineering there. And when I graduated, I got a job as a lecturer at the City College of New York and also as a lecturer in the art department at Hunter College in New York. And I picked up a wife shortly before that, and then started my graduate work. And the way it worked in those days, people would teach at the city college during the day and then sort of go to evening school. It wasn't really night school. The classes at Columbia University would start, like, at four in the afternoon or six. So, I did my master's that way, teaching at City College and studying at Columbia, also in mechanical engineering. And then I went on for my PhD under a similar system. And when I got to within, say, two years of the end of my PhD, I left the job at City College and got some financial support through a fellowship at Columbia and finished my PhD there. And then after I graduated, by then I had accumulated two children in addition to the wife, and moved out to California, to Stanford, to take my job this 1962. And here I am, never left since. So that's kind of...

Q: What was your PhD thesis work on?

Bernie Roth: It was an area called kinematics. It was the science of motion. And I did something called synthesis of mechanisms, which was basically the idea of someone gives you some requirements, and you figure out what the dimensions of the mechanisms should be. And in that, I developed something called continuation method, which became kind of a very famous mathematical way of solving nonlinear equations. So it was basically using computers very early on. I was probably the first of my cohorts to use computers. And the machines we used were the IBM 650s, that had 2000-word memory. And somewhere in my thesis that wasn't big enough, so I found a machine with a double memory, so with 4000 words. And it was up in a physics lab Upstate New York, where they were looking at bubble chambers, so they needed to have better calculations. But if you went at three in the morning, so from three to five in the morning, I could get the machine. So, that was my life as a graduate student.

W1: Where was it in Upstate New York?

Bernie Roth: It's right near where the Headless Horseman was.

Q: Sleepy Hollow.

Bernie Roth: That's right. Sleepy Hollow, all that. It's on the Hudson. It was – I forget what it was called. It was a little bit above Hastings on the Hudson, but it was, I forget the name of the city. But Columbia University had a lab there, and that's where it was, yeah.

Q: And how did you wind up at Stanford?

Bernie Roth: Oh, that's an interesting story, in that there's no way I was going to leave New York, because they offered me assistant professorship at Columbia, and I was pleased to take it. And my professor was like, it was the best place to be for the field. But the problem was I was saddled with this wife, who, she was switched at birth, and she ended up in New York, but she wasn't supposed to be. So, but basically, in spite of that, I was going to stay there. And my thesis professor at the time, before the Columbia thing was settled, said, "You know, you'd better hedge your bets, so probably you could stay here, but let's look around a little bit." And among the things he said, "You know, I met some guy from Stanford at a conference, and you know, they're building up. Maybe I should contact him." So, he contacted him, and it turns out the guy he met was – there were two people at Stanford with the same name. And this one fellow had come to this conference even though it wasn't his field, but it was a free trip to Yale. So he went there, and it was totally the wrong guy. But when the request came, he was decent enough to pass it on to the right person.

And so I came out thinking, you know, it was just a free trip to California, which the world owed me after I'd worked so hard on my thesis. And we came here in August, and it was a little bit unbelievable in the way people get jobs now are very – you have to give talks and all this stuff. But somehow I met these people, and we talked, and they gave me lunch. And one guy asked me a trick question, and then after lunch they shook my hand and offered me a job at the princely sum of 8000 dollars a year. And so, then I had this job. But I had this other job at Columbia University. So, all, we went by train. I was afraid to fly in those days. So, all the way back, I stewed with, what am I going to do? It's my thesis advisor. This is the end of August, and Columbia, they start the beginning of September. It's like two weeks away. So, when I came back, they said, "What happened?" I said, "Well, they offered me a job." And they said, "Well, we've been talking about it, and Stanford's really building up. It's the place of the future. You should take it." So, it kind of took the burden off me, you know. So, I took it, which was – so, we packed up and three weeks later, we were in California. So, it was kind of a quick thing. And my life has been happily ever after here. And I've been pining away from New York, but I've been enjoying it a lot here also.

Q: So, who were the people you had lunch with that day?

Bernie Roth: Oh, it was funny. One was the dean, a guy, Joe Pettit, who eventually became president of Georgia Tech. So, he was the dean. And a guy Bob Cannon, who was sort of a hero, astro-controls guy, who actually ended up doing some work for robotics. And Tom Cane, who was a professor, a young full professor in dynamics, and he had graduated from Columbia, so he was some of the connection. But he's the one who asked me the trick question, because his field was close to mine, you know. And then there was Will Kays, who was the chairman of mechanical engineering. So, those were the people I had lunch with.

W1: Do you remember the question?

Bernie Roth: I do. I do. Yeah. The question is: If you have a particle moving in a circle, what is its angular velocity. And the answer is: Particles don't have angular velocities, only bodies do. That was the trick question.

W1: <laughs>

Bernie Roth: But then to hedge my bet, I said, "But you could imagine, you know, connecting a rod to it and going around, and then the rod would have an angular velocity, and you could get it." That was that. But many years later, when Tom retired here, I went to his retirement party, and he pulled me aside. He said, "You know, I didn't regret for one day at all that you came here." So, I mean, he was happy I'd passed the trick question. <laughs>

Q: And so you joined the mechanical engineering department.

Bernie Roth: I joined the mechanical engineering department. And actually, I was very interested in dynamics and stuff, but the way Stanford worked at that time, the department was broken into different groups called divisions. And there was an applied mechanics division, and they controlled dynamics; in fact, Tom did there. So, there was no real space to teach that stuff. So I ended up teaching the kinematics, which was kind of what my thesis was on also. So I became Stanford's kinematics guy. And that was that. And then I was – the job, though, to get the job, I had to kind of exaggerate my interest in design, which wasn't very existing at that time. But so I had to exaggerate in the letter how I would be interested in that. And like life is, once you exaggerate, you become that. So, then I became much more both involved in and interested in design; it's become the biggest part of my career, but it didn't start that way. My career was more towards what's called applied mechanics. That was more the value system I had been educated with.

W1: And so, you mentioned that previously you had been at Hunter College in art.

Bernie Roth: Yeah. Art, yeah, that was a great thing.

W1: How did, yeah, what did you...

Bernie Roth: Well, I taught drafting. I taught drafting. But the great thing about there, this was like, this was, you know, in the late '50s. There was a woman chairman and a male secretary. It was kind of ahead of its time. <laughs> So, that was the most distinguishing thing about the art department at Hunter. But I taught, I sort of – people would always do that, thinking New York has so many schools, so you teach in one and then you'd kind of moonlight in another. But I for many years taught drafting at Hunter in the art department.

Q: How did you first become involved with robotics?

Bernie Roth: Yeah. That's another one of these life things which are accidents that change your whole life. I was a young professor. I'd been here, say, two years, if that long. I was minding my own business, and I got a phone call. And at the other end was this august figure, Frederick Terman, who was provost to his, like, famous and sort of autocratic reputation. And, you know, I say, "Yes, Sir". And it turns out that John McCarthy, who was the professor of computer science, also a young professor, he had gotten a big grant, like a million dollars, which was a lot of money in those days, to start what was called the Stanford Artificial Intelligence Laboratory. And part of the thing was that they were going to build robots. And somehow, Terman, who kind of had his ear to all the vibrations, got some word from someone that John was a great mathematician but maybe not the right guy to build mechanical things and that he ought to provide some backup or something like that. So, he called me and he suggested I get in touch with John McCarthy. And I think he called John and suggested he get in touch with me. And so we got in touch with each other, and the rest is history.

So, you know, we met and I sort of took on the part of the projects that would involve building mechanical arms, which is what we called robots in those days. And, you know, I had no knowledge of it or interest in it or anything about it, but it seemed really nice and seemed something that would be in the area that I could easily handle the stuff. So, I started to essentially supply – and the idea was to supply mechanical arms that they could whiz around with the computers. And they had the illusion, the computer guys, that they could do anything. And, you know, you didn't have to worry about the mechanical things. They just could do anything at any speeds, and they had all these exaggerated notions of catching flies in the air and stuff like that. <laughs> So, you know, we decided we would do that. And they were very anxious to get started. So, the first thing I did is I knew of a prosthetic arm. It's sort of like an arm brace, essentially, but it had electric motors. It was for people that were paralyzed, and it had a tongue switch. So, with your tongue, you could control the motors and you could get your arm to move. And there were some people down in Los Angeles, or Rancho Los Amigos

Hospital that had this thing. So, and I had some contact with them. So I contacted them, and they agreed to sell us one. I think, I don't remember the price, it was maybe two thousand dollars, maybe less. So, they sold us this arm, and my students and I kind of adapted it for computer control. And we called it the Rancho Arm because that's where it came from. And it turns out it was very, very flimsy because it relied on the structure of the human arm to give it, you know, strength and stability. So, without an arm in it, if you moved it, it would vibrate, you know. So, after a while, we would get the people who called it Shaky. And then when we put a mechanical – we put a hand on it, it would drop stuff, so they called it Butter Fingers. It had various different names at the time.

But basically, that got us into the business very quickly of being able to have a computer control an arm. And that was the objective, to just get going as quickly as we could. And a series of experiments were done, and there were movies, very early movies made. And I always laugh about one of them. There was a fellow, his name was, I think, Gary Feldman, Gary, who became this physician afterward. And Gary was the ace film maker. And we're up there filming one night, and he was, as a film maker, you know, you do a lot of cuts and stuff like that. And so, I said to Gary at one point, "Gary, this film is one big fraud." And he said, "No, no, Bernie, it's a lot of little frauds," which I always remembered, which is, you know, kind of film, so, you know, you cover something and you'd stop it and you'd move the blocks and all that. But there were serious experiments which had to do with stacking blocks and using – there was another part of the project which had to do with vision. So they used the cameras and tried to detect the world and use vision to measure where things were.

So the idea was to merge the two projects and use vision to essentially direct where you move the arm and then pick up blocks and move them. And there was a whole series of experiment. And they were kind of nice little movies made that way of block stacking. And then there was always this – those were the days of the Beatles and all this, so it was always just tongue in cheek, you know. "Help," you know that movie? You know, the movie's always got to be a little bit out of control, which was different from most technical movies. And it was a kind of nice thing I liked a lot. All the movies that were made here were kind of, they had a little bit of pizzazz in them and, you know, not only the music but <inaudible>. So, there was this stacking of the blocks, and you know, it's doing this whole thing. And then there's this cut. And then there's like a picture of what's impossible. Like the block is so cantilevered off, it couldn't possibly be standing there, you know. It's a kind of, you know, visual joke or stuff like that. So, there were a lot of things like that. So, we had a lot of fun. We'd make them all night long. It was a lot of fun doing that.

And in addition to that, the thought was to make an arm more suitable to the computer. And the idea came up, well, the computer is digital, basically, so why are we taking the efforts to convert the digital information to analog information to control these motors? Why don't we just make a digital arm? And the idea evolved with, we had little bags, so you kind of basically blow

them up. And there'd be two positions. The bag would either be deflated or totally inflated. So that's how we arranged it. And so, we made an arm which had all these little baggies, which were actuators and by just actuating on, off and all that, it was this very snake-like structure, and you could get it to go from one position to the other, of course. And when it went from one to the other, it would move dramatically. It wasn't like slight motions and stuff like that. So, we had that time a graduate student here from Norway, and he said – we were trying to think of a name for this thing – and he said, "The Norwegian word for snake is orm, O-R-M." So that was it, naturally. So, this became the ORM, you know, and very clever, right? You know, as opposed to the arm, right? So, we worked with that for a while, and it turned out to be not a great idea at the time, and it had a lot of issues. But, it did have the idea of this digital control in the segments. And many years later, some people picked it up, Greg Chirikjian especially at Johns Hopkins did a lot of work with that. He had different actuators, but it was a similar structure thing, but we were ahead of our time with that one. But we did have the idea that the speed was supposed to be the issue, because the computers were going to do everything so quickly.

So, the other projects which we moved on were, some used hydraulics, which could give us the most speed possible, and we built a hydraulic arm. And we had to design the actuators and all that, and that was quite successful. And it was scary, because it was this really powerful thing, and there was always a lot of concern about people getting hurt. So, we built a room around this arm, and we put the hydraulic room in, and I was very cautious. So, I made sure the students bought shatter-proof glass to put in, especially near the controller. Some years later, I found out that they had dropped a piece of the shatter-proof glass on the way in and they didn't want to tell me, so they replaced the one right in front of the controller with ordinary glass. But nothing had happened, so that was okay. <laughs> There were remarkably few accidents, I must say, given what went on. And there was always this stuff of having to get into the room and, you know, you try and put safety locks and people didn't want to take the trouble and stuff like that. But we did get the hydraulic arm working. And there was a student who wrote his thesis on that, Mike Kahn on this, and it turned out to be the first thesis on dynamics of manipulators and control and stuff like that. And that was good, and it was nice work. And before that, there had been, or sort of simultaneously, it was Don Piper, who was another student of mine who, he worked on the kinematic issues of just arms in general.

So, I had this idea, like, you know, we ought to make a science out of this thing, not just build devices. And so, the idea was to try and just start and look at stuff very basically and build up a theory. And I had a good background because I had been working on three-dimensional mechanisms. And an arm is basically a three-dimensional mechanism. So it was very easy to apply a lot of the things that I was teaching and familiar with into this work. So, it kind of was a good, good fit that way. So, Don Piper did his thesis basically on the kinematics of arms in general and how you could control these, we call them serial manipulators. So, if you wanted to go from here to there, how much do you have to move the motors and stuff, and that's called the direct problem. And then there was the inverse kinematic problem, which is the hard one, which

is: If you know where you are, how do you figure out where all the motors should be to get the hand where you want it to be? So we worked on that and we had some good progress on that. And we had Mike Kahn's dynamics, so it was a really good start on the basic idea, the kinematics, descriptions and stuff. And I remember at one point, I think it was Mike had finished, John McCarthy at some meeting said, "You know, we've turned out a few really good theses in mechanical engineering. Why don't we turn out something in computer science," which is what the lab was about; it was the AI lab. And they did. But I remember, we were kind of a little bit ahead of the curve on that stuff. He quipped that way. I always remembered that remark.

But then the people came along, and we kept working. There was Lou Paul, who became very famous and kind of wrote the first book. And that was kind of interesting, because I always thought of the subject as being, you know, if you're going to learn robotics, you should learn kinematics. You should learn dynamics. You should learn controls. These are all subjects, and they're all right. And then Lou came along, and he kind of stuck it all in one book. And I thought, well, you know, that's kind of like, you know, it's not really thorough and dense and all that kind of stuff. And, you know, it took some convincing, but he was right, so it was probably the way to go. And some years later, I actually paid one of my researchers, John Craig, wrote a book, which was kind of a follow-up on Lou's, so I actually funded it. So I believed in it. But I must say, when it started out, I thought it was too much like a survey course. I didn't like that idea. I thought it should be more in depth. It is a survey course, and I've taught it many times here. And it isn't in depth, but it seems to work well, so it's fine. So, let's see. What else? You know, a lot of people came along. I don't know if you want me to go through.

Q: Yeah.

Bernie Roth: Let's go through. Okay.

W1: Yeah. And if you could even tell us the names of some of the people. Like, so, who were all of the students?

Bernie Roth: Say it again?

W1: Maybe you don't remember all the students.

Bernie Roth: Yeah. Sure I do.

W1: But who are the other students who worked on these things?

Bernie Roth: Yeah. Sure. Well, as I said, my original students, actually this is a little complicated story, but it goes like this. So, I had Don Piper, and he finished up, and Mike Kahn was still working. He was a little bit behind. You know, he had an experimental thing, the arm and just a little. So I had my sabbatical, I had my first sabbatical, and I wasn't going to miss that. So I went off to Holland. And before that, Vic Scheinman came along, and we were going to build another arm. And this was going to be an electric arm. And so, we started to work on that, and Vic was, he was kind of acting like a contractor, but he was working for the project and all that. And he was going to do a PhD. So, I had Vic and Mike, and I was going off on sabbatical, so what to do. So I had another graduate student, Ken Waldron, who later on became very famous in walking machines and stuff. And Ken was actually my second PhD student, but Ken's work was in the kinematics area. He really wasn't working in robotics. But I was going on sabbatical, and the idea was Ken was just finishing up, would kind of replace me and teach my courses, and he would be like an acting assistant professor. And he would kind of take over and all that. So, Ken kind of took over. I went away. I went to Holland, and I was at Technical University of Delft. And Ken was working with Vic basically. And Vic ended up doing what we call an engineer's degree, which has this kind of thesis to it, or a master's. I forget exactly if it's a master's.

But at any way, Ken kind of ended up doing that, then supervising Vic on writing the – see, I guess it was an engineer's degree. I'm not exactly sure. So Vic did this arm, which got called the Scheinman arm, which was this electric arm, which became sort of our bread and butter arm for many years. And he sold some other copies. And being Vic, instead of making four gears, it was cheaper to make ten gears, so he got more parts than he needed actually, and then he started to make them. And he actually started a little company called Vicarm. He then got involved with Marvin Minski, who was sort of the MIT twin to John McCarthy. And Marvin had started a similar project, the artificial intelligence project in MIT. But he didn't really have any arm people there, so he kind of hired Vic. And Vic, who had had at MIT, always loved MIT much more than he loved Stanford, I think, and so he was glad to go back there, and he worked for Marvin for a year or so. And he made a small version of the, we called the Scheinman arm. He made a small arm for Marvin. He made another kind of arm that folded. So he did some designs there, and then he came back here and eventually started his company here. And so, we had the electric arm that Vic had on the Scheinman arm. Then he built force. He built one of the early force risk –forced six axis forced torque measuring devices, built hands.

We had other students. I had one student, Lung-Wen Tsai who did a kinematics degree, but it was hard. He was from Taiwan. It was a little tough time to get a job. So, to keep him on ice for a while, we put him in the lab, and he built the fixtures for what we called the flashlight factory. It was a film we made of assembling a flashlight using the arm, the electric arm. And Lung-Wen built all the fixtures, did some of the designs. So, we had a lot of students who helped out in different ways on that. And Vic was really close to Bruce Shimano, who was another graduate student of mine. And Bruce was kind of the – did a lot of the programming for Vick's company and all that. It's still going on to this day. <laughs> So Bruce was involved.

Bruce did a really nice thesis, which was sort of the kinematics of the arms. He showed what position it's in when it reaches furthest out, what the conditions are, and things like that. And so he was there. I'm trying to think who else came along then. Oh, Jeff Kerr was another student. He worked on the hand. We did – let's go back. I skipped – so before Ken Salisbury, who's also around as you know, Ken was working with me on the hand. And at about the same time there was an electrical engineering student named John Craig who was working at the AI project. And he had some difficulty there. And eventually he came over, and he became my advisee. So I had John and I had Jeff Kerr. And there was Bruce Shimano, who was kind of just finished up.

And then I had a fellow Madhu Raghavan who was also there at the same time. And so Jeff was working on hands, following up the work that Ken Salisbury had done on hands. So Ken did like the original thesis on hands and the original kinematics about the hands and all of that. And then Jeff got into like the forces, the gripping, the control. So Ken was – so Salisbury was more the structure of the hand, how many fingers, and how many joints, and that kind of thing, and what the different poses are. And Jeff was more into the how you hold it and those kind of things. And then John Craig was interested in control of the hand – of the arm and stuff like that. So John worked in that way. And Madhu was just doing a kinematics thing and all that. And then it turned out when he was done, he couldn't get a job for a while, so we put him on hold. And he did this thing where he kind of cracked open the problem of the inverse kinematics that we were working on for a long time. And that was after his thesis. That was just while he was on hold. So then he became kind of a robotics person. And he's at GM research now doing quite well. So eventually John finished, and he was going to become a professor at Berkeley in EE. And at the last minute he got cold feet and took a job with a startup company where they were doing software, which he had been freelancing with. And he decided he'd stay with his friends in Silicon Valley. So he was there.

And then – just trying to – there's so many pieces. I'm trying to get it all in some sort of an order, but – Vic – After Vicarm, Vic sort of got involved with Joe Engelberger who – it's a little bit complicated, so we'll just go back a little bit. There's a guy called Devol. And he had a very strong tie with Engelberger. And Devol's idea was the buy up all possible patents and control robotic patents and stuff like that. And when he heard that we were doing work in robotics, he came out here. He was very interested, and he sort insisted on giving money for fellowship for a student. And I used that to support Vic Scheinman. So Vic kind of got to know George Devol, and through that we got to know Joe Engelberger. And so when Vic started his company, Joe knew him and all that. And at one point, Joe sort of asked Vic's company – he sort of bought Vic's company and made it the West Coast division of his company, Unimation. So he made the West Coast wing of his company, and he got a contract with General Motors to make what became called the Puma arm. And so Vic, essentially, designed that there. And at one point Vic was going to take a partner. And I knew this partner. And I knew Vic very well. And I thought this is the world's biggest disaster about to happen. So I'm usually very passive with my children and my students. But I felt this required an intervention. And so this young man walked into my office who was doing a dual degree in electrical engineering and mechanical

engineering, who I thought very highly of and who was interested in starting a furniture company, and all that. And I told him, “You ought to talk to Vic.” And I brought them together. And that was Brian. And so – Brian Carlisle. And he went to work with Vic. And then, eventually, Bruce graduated. He went to work there.

So the three of them were together. And they were the West Coast division of Unimation. And then Vic had a buddy who he knew from family ties and all that, who was starting a company, Automatix. So he kind of went to Automatix to help with this company, left Brian and Bruce alone. And then eventually, Engelberger sold Unimation to Westinghouse, and that didn't work out. So they made a deal, Brian and Bruce, for Westinghouse to essentially be able to keep their intellectual property for – exchange for some shares to Westinghouse. And then they started their company out here. So that was kind of how all that kind of shook out. And Vic kind of was busy with his Automatix company. And they went off that way. So, let's see what else at the same time? Who else? I'm sure I'm forgetting some people that are very important in my life in robotics. I'm trying to think what other students worked in robotics. I mean at a lot of points a lot of the kinematics and robotics, and the controls kind of melded. So it's really hard to say who distinctly was in one area. But I'm trying to think...

Q: When did you start calling it robotics?

Bernie Roth: When did we start –? Well, it was – it always bothered me somewhat, the whole idea of the robot arm thing. And many of my early papers I kept using the word manipulative mechanical arm, and stuff like that. And, eventually, it was just a losing battle. So I stopped worrying about it. But it's – what is a robot? I think I've said this many times. A robot is – if your dishwasher has a little computer in it, is it a robot? So it just turns out it became what was convenient for commercial interests to call it, and for interests to want to get grants to call it. So if robotics was in, then you call it robot. If it wasn't, then you'd call it a mechatronic device, or electrical-mechanical device. So there was a kind of political things to it. But, you know, it's life. But it's just a shorthand word.

Let me think about who else. Oh, yeah, actually Vic is still a good friend of his, Lawrenson [ph?], Irv Lawrenson. Yeah. Vic actually visits him and stays at his house in Norway. Actually he went last year and totally ruined his back on a cross-country ski trip there. Yeah, you can ask – Irv Lawrenson was the – <audio interrupted>

Q: Is he still in robotics?

Bernie Roth: Irv? No, he's sort of medical – he was just helping us out here. He was just doing a Master's thesis – not a thesis, just a Master's degree. And he was just in the lab helping us out. I

think, I would say he was always in healthcare kind of things. But Vic knows him much better than I do. I've seen –

Q: When you were at Delft, where you building a robotics system there?

Bernie Roth: No, Delft was pure math. I was with – the guy I was with was a mathematician who was mainly – it was the beginning of a book I wrote called “Theoretical Kinematics”. And that’s what I was doing at Delft. So it was basically sort of algebraic geometry and stuff like that. So some of the tools we used, but it really had nothing to do with that. Yeah. So the interesting – I should mention, when I was in Delft, I went to a conference toward the end of my stay there, which was the founding conference of an international organization called IFTOMM, the International Federation of the Theory of Machines and Mechanisms. And at that conference I presented one of the movies we’d made at the AI lab about robot – one of these movies of stacking blocks and stuff like that. And I presented some of the stuff that we developed for Don Pieper’s thesis, and some of Vic’s stuff, so just a little summary of our work. And one of the people there was a guy called Ivan Ivanovich Artobolevskii. And he was a very, very prominent in the Soviet Union. He was a member of the Supreme Soviet, which is – and he wasn’t a member of the party, which was really very unusual. And so he was like a very – he was sort of the head of the Mechanical Sciences for the Academy of Science. And he was very taken by <inaudible>– he came up and congratulated me afterward, and all that.

And I actually went after that – I had a – some months after that I was still on sabbatical. My wife and I went to the Soviet Union. I had a U.S.-Soviet Academy exchange. And I went there and I met this Artobolevskii had an apartment one block from the Kremlin, you know, it was heavy-duty stuff. And there was with him a fellow, Kobrinsky – Aron Kobrinsky, who I met for the first time. And it was kind of funny. So I met him and we formed a kind of close friendship because there was this incident where – it was something about an Easter egg or something. Artobolevskii invited us to his apartment for lunch. And there was something about an Easter egg. And my wife, says, “Oh no we don’t cel –“ He said, “Do you celebrate Easter?” I said, “No, we don’t celebrate Easter, we’re Jewish.” And afterward Kobrinsky came to us he said, “Oh I was so proud when you said you were Jewish.” He was Jewish, but he was undercover. So there was formed this big bond. And probably also got me watched by – got followed by guys in raincoats just like in the movies, and all that.

But we started a discussion about there should be a kind of East-West exchange in robotic area and all that. And that led, eventually, there was a meeting about – yeah, about four years later there was a meeting in Yugoslavia, second IFTOMM World Congress. And these guys were ready when I got there. They had prepared this whole idea of making a set of conferences on robotics and housing it in a place call CISM, which is in Italy, which is in – CISM is – that’s Italian, C is Center International Science – Scienta Mechanica. So it’s a – was

an international center for mechanical sciences in northern Italy, in a city called Udine. And they brought to this meeting the guy who is the head of that. And it was kind of – we came together. We decided to form a steering committee and to have a set of meetings. And my friend Kobrinsky who was very brilliant and very imaginative, he said, “Let’s call it Romansy.” For Robot, Manipulated, Symposium. And the Italian guy said, “No, no that’s not serious.” It was so funny. It was total culture – you’d think the Italian guy would say Romans – but he was sort of uptight. But anyway it became Romansy and to compromise we put a period after Ro and after the n. so it wasn’t one word, but everyone calls it Romansy. And shortly thereafter, after Yugoslavia meeting, two years after that we started the Romansy series of meetings. And they were quite good in that they actually broke this East-West thing, where we could actually be at meetings and talk about that. And the Russians starting building up a lot. They were very good in walking machines and stuff like that. And the Yugoslavs came. So that was a nice series and I was – nice to be involved.

A really funny thing about it, which is kind of an interesting sideline, is I was in charge of the U.S. thing, but they were nervous because I was very young. And I had very long hair. They said they thought I was a guitar player or something like that. So they didn’t know I was just fashionable. <laughs> So they said somehow couldn’t I get another American, so they wrote to the Controls. So they got Dan Whitney who was at MIT – he ended up at Draper Labs, at the time he was at MIT. So Dan and I became the U.S. committee. And Dan kind of never did much with it. You know he kind of – but that was the first conference. So Dan and I were the U.S. committee. And then at the end of the first conference we had – and they had made Kobrinsky the chairman of the first meeting. But they didn’t let him come. They wouldn’t give him an exit visa, which was kind of – I was irate. And these guys would come up to me and I would say, “Where is Aron?” And they’d say, “Well his brother’s very sick.” You know just pure bullshit, lying right to your face. And it was like, oh god. But, you know, that was their circumstance.

Anyway, so I was sitting there at – we had a lunch, like a committee lunch at the end of the meeting. And Artobolevskii’s out front. And I’m sitting in the back enjoying the wine, kind of flaked out. He says – and this is like the voice of god, this guy. I mean he was like a very powerful figure. And he says for the next chairman I propose Professor Roth. And I’m kind of – I wake up. I was this young guy. It was like the most charitable act. You know, it was good for my career and all that. But it was like this guy, he didn’t have to do it, you know. He was, you know, Russians had a turn – a turn and all that. So that was kind of a very moving thing for me. And so I became the chairman of this thing and the committee and all that. And I was involved with it for a very long time. And at it I met two young guys. One was this very tall Italian guy who was chasing all the girls, called Bruno Siciliano. And he was a graduate student. And I met earlier a fellow called Oussama Khatib who was presenting his thesis by putting the slides down for his professor to talk about it. And Oussama spoke no English at the time, but somehow said could he come to Stanford for post-doc. And I said that was fine. So that was my connection with him. And then, actually, I also met at one of those conferences, Jadran Lenarčič. You may or

may not know Jadran, but he's the head of the biggest lab in Slovenia now, the biggest research lab.

And so I met – at this conference I met various people, kind of was nice place to meet – who became very good friends and stuff like that. So there was a whole series of conferences. And then they moved. They would go – it turns out the CISM people had membership from different countries. But the Eastern European countries, especially the Poles paid with their currency, which was not convertible at the time. So CISM had a lot of money in Eastern Europe that they couldn't do anything with. So they wanted to put meetings there, and they could buy you tickets on LOT Airlines to fly from New York to Poland. So I made a lot of trips to Poland, which I enjoyed a lot. And we had a lot of meeting and committee meetings there. And we would move – the Romansy would go from Poland – it was every two years, the meeting. And it would go, every fourth year it would come back to Udine and go there. Now they've moved it to – it goes all over.

So eventually, I figured I've been there long enough and someone else should take over. So Ken Waldron had joined the committee, and then Oussama – when I left Oussama Khatib because he was at Stanford, he came on the committee and all that. So Oussama and Ken have been very instrumental in that. And they've moved it all over the world. But in my days it was just always in those two places. And then Jadran, this fellow I mentioned to you, came to me and said, "Well, I want to start a thing on robot kinematics, and I'd like you to be the scientific chair." So, he was a good friend. I couldn't say no. So I do that. And that's been great, too. So we have that now every two years. And it's this thing it goes – it's in Slovenia, and then it goes somewhere else. And originally it was supposed to be just in the area around what they call Julian Alps, the Alps around – the Alps in that area. But it's moved around a little bit more. It's been down to Bologna. And it's been in France. It's been in Spain. And that's a nice meeting, but it focuses on just a specialty of robot kinematics. Romansy was a more general meeting, also robotics sort of with a mechanical twist to it, but it had controls, it had some vision, it had walking machines, it had more of that. And it had a lot more dynamics and controls. So those are two meetings the sort of sprung out of this kind of activity and the visiting of – and it all kind of in my mind sprung from this first visit to this – my sabbatical where I wasn't doing robotics. But it ended up, at this IFTOMM meeting, it all switched that way for me.

Q: What year was that first meeting?

Bernie Roth: That meeting was 60 – the sabbatical was '68, '69. So that meeting must have been in the spring of '69. Yeah. So, yeah. Let's see what else I can tell you. Oh, yes so the Chinese guy – so I had three – like one, two, three students from the mainland China in sequence and somewhat together. They basically worked on robotics also in terms of hands and kind of just the grasp problems and things like that. And that was kind of fun, in one way. I have this one

student, he was very unusual. He was very non-Chinese. Most Chinese students come here, they save their money, and they're going to go home. And they're very serious. And this guy was like – I always meet my students once a week. And this guy was not showing up, and on and on. So I finally told him, I said, "You know, I don't think this is working out. I think you ought to get another advisor." He says, "No, no, no, no." And I said, "All right, well, you've got to come to the meeting. And if you miss another meeting, we're finished." And he was so Westernized that he says, "That's not fair." He says, "We should do like the –" By now he had a car. He said, "We should do like they do with the motor vehicle bureau. It's like certain points for certain offenses. And I have to be allowed the maximum of points," which I loved. How could you not love it? So it worked our fine, but I always remember that. <laughs>

Q: Did he go into politics later?

Bernie Roth: That was great. Shows he was very Americanized. But it was funny. Yeah. Then I had a guy from Bulgaria who was also kind of interesting. He came and he did a nice thing on – thesis on sort of the problem of manipulator workspace kind of – manipu – workspace kind of problem. But had to do with multiple telescoping arms and things like that. And the thing I liked about him, which is these cultural experiences for me, this guy comes here, and he figures out right away he can't do anything without a credit card. So he says would I co-sign a credit card with him? Co-own. So I said okay, but I won't use it at all, just it's your card, your responsibility, but I'll co-sign with you. And then he comes to me and he says, "You know, there's this thing I can – if I give them ten dollars I can – by virtue – since I bought the card, if I give them ten dollars, I can enter the Canadian lottery," and all that. And I go, "That's a sucker thing. You don't want to do that." So, of course, he didn't listen to me. And he won 60 thousand dollars, <laughs> which is so funny. Which, you know, who would do that kind of thing? So that was great.

Q: Didn't give you half, though.

Bernie Roth: No, he didn't. But he used it to get married. It was kind of a funny story. He married one of the – he was TAing for me, and somehow – it's kind of a funny story. So anyway all of these things are kind of cute along the way. Let's see what are – who are the – I'm sure I'm missing some students. I should probably take a moment out and go look at my list of papers and see if I'm leaving someone out. Would that be good for you?

Q: Sure, if you'd like to.

Bernie Roth: Yeah, is that all right?

Q: Sure, no problem.

<break in audio>

Bernie Roth: And I'm trying to think who would be alive. Artobolevskii's dead. I mean all – our whole group that – I was a young guy. I was this young kid. And they were all – they got there ahead of me. So I'm trying to think who – there's a guy – he probably does n – there's a guy, Alizade, who's a – he's not a Russian, he's a Azerbaijani. And he works in Turkey now, in Izmir. He's a professor at Izmir. But he was young, I don't know what he knows – but he may know them all. He might be worth – His first name is Rasim, Rasim Alizade. I could probably get you his email if you need it. A-L-I-Z-A-D-E.

Q: I can probably find it online. If I can't, I'll just email you and ask.

Bernie Roth: So and there's also Yuri Sargsyan. He's Armenian. And Yuri knew them all very well. He became the head of a school – he's like a politician, but he knew these people. And he's kind of older. So let me just looking at all my co-authors to make sure I haven't missed anyone. I don't know; how do you want to do this? Should I just do it in – and you'll cut it in or –

Q: Yeah, we'll edit the whole thing. Don't worry about –

Bernie Roth: So another student I had is – his name was Morgan Ohwovoriole. And he came from Africa, in Nigeria. And I told him when I learned how to pronounce his name he could graduate. And he actually, he was interested in politics. So he actually changed his name from Morgan to Ejevo so he'd have a tribal name when he went back. His father and his grandfather had been chiefs and all that. And he did a thesis, which I loved a lot, having to do with the grasping, and the forces, and the idea of grasp and stuff like that. And nobody could understand that, so Mike Brady and some other people at MIT once said, "Why don't you write a paper that we could all understand?" or something like that. So I wrote a paper where I loved the title. And the title was, "Screws, Wrenches, and Motors that you cannot find at the hardware store." And the idea is these are mathematical names for things. And that was based on the work I did with Ejevo. Unfortunately, he just died last year. So but that was one that we left out. I'm leaving out all my kinematics guys because we're just interested in robots. So – Jeff, Jeff, Jeff –

Bernie Roth: Okay, so at one point I got invited to go to Paris to have a laboratory of robotics at Paris and to spend a month there every year, basically. And so I started doing that, and I – the first year I was there, there was a graduate student there from – he was a Greek student who was a foreign student in France. And he was getting his Master's thesis. And I ended up supervising his thesis. So I gave him a robotics problem having to with sort of different ways that you can

describe a wrist, positions and stuff. And that was successful and all that. And when I came back, he wanted to do a Ph.D. thesis the next year. He started doing that. And he was interested in the kinds of things I was interested. So I ended up supervising it. So I had this funny situation where I had this Greek student in France where he had French thesis – then at one point I went to Japan for some time, so he came to Japan. He came to Stanford. He kind of followed me all around the world. And he ended up with a thesis, which had to do with special geometries for manipulators and all that. His name's Mavroidis, and he's a professor – he actually – afterward, he went to MIT. And he worked as a research associate with Steve Dubowsky for awhile. Then he was a professor in New Jersey. And now he's at Northeastern University. And so that was just an interesting – very pleasurable kind of unusual association that way.

Let's see what else I can figure out. <pause> I omitted – yeah I had – well there was a lot of people came like as post docs and stuff like that. We did little things together, but in terms of doctoral students I had a fellow from Brazil, Mitone [ph?]. I had another American, Neilsen. We worked on different problems. I think that's about – yeah, I think that's about – so, the main thing is that – that's kind of missing from the story. We won't go there a lot is that there are a lot of people like Mike McCarthy, for example, who did a thesis with me in pure kinematics and then their careers turned out to be robotics, a lot and stuff like that. So there'd be people like that all over the place. And I haven't mentioned those. So, sorry guys. It just – I wanted to just stick with the direct robotics story. And, yeah.

Q: Who else did you collaborate with in terms of faculty or other labs?

Bernie Roth: Here? Well, there were different things that I spent – I twice had a fellowship in Japan. So I worked there with Professor Inoue in Tokyo, and then also just a series of people there that – Shigeo Hirose was a very close friend and contact of mine. I worked in his lab. I was in France at LAAS – it's in Toulouse. It's a big robotics lab. Georges Giralt was the head of that. Raja Chatila is the head now, we're very good friends. There were a lot of people there I worked with a little bit. So just – I've gone around the world a lot of times. So there've been a lot of places I've worked for some time. I was a visiting professor in India a couple of times, in Bangalore. One of my ex-students that I mentioned Ashitava Ghosal he's a professor there. He does a lot of robotic work. The work he did with me here was more kinematics. He's another example. So I've been to India a lot of times. I was visiting professor at Kanpur, Bangalore, and New Delhi. I've been to all the IIT's there. And I used to go to Eastern Europe a lot. I've been to Turkey a lot of times, Middle Eastern Technical University. So I don't know, just endless. So I'd say, the only – Oussama Khatib who came here as my post doc, without speaking English. In the first year we kind of mainly had French around because John Craig spoke French and Oussama spoke French. And yeah there was a lot of French around. So you know I've collaborated a lot with Oussama afterward when he became – I tell him he's the man who came for dinner and never left. And so he's been – so I've collaborated with him a lot in recent years. With him we had some students that – Mike Zinn we did this – we just did a thing on special ways of driving

manipulators so that you don't have as many inertial effects and things like that. And Mike is now a professor at Wisconsin. So Oussama and I co-advised Mike. I don't know. So there's a lot.

But, in general, these are all short – Oussama and that collaboration with that lab goes way back from John McCarthy, so it's just always different people there. And Stanford's a place that's really nice in that there's a lot of permeability between the boundaries in departments. So often like Joel Burdick who I didn't mention – Joel Burdick was my student. And he got his Ph.D. in ME, but mainly he worked in the lab there. And he worked very closely with Oussama. And he did a thesis, which was basically based on – he did enough to do two or three theses. But basically it had to do with manipulator kinematics. He did a dynamics work and stuff. But he was an example of someone who's basically based down in that lab in computer science, but was an ME student. And there's a whole generation of – many generations of students of like that. Ken Salisbury was that way. Shimano was that way. There are just a whole string of them who did that. So that's in a way a collaboration, but it's internal. I didn't really have – externally, well there were people like K.C Gupta at the University of Illinois. He was a student of mine. We've over the years written a lot of papers together, some of them on robotics. Although K.C's original work was on kinematics. So it kind of – I don't know. Bahram Ravani up at Davis, another ex-student. As I said, Mike McCarthy down at Irvine is another ex-student. I don't know they were all over the place. There's this one Neilson who just graduated a few years back. So, I don't know what else I can tell you.

Q: So what other kind of robotic mechanisms did you work with? You mentioned in the beginning a few different iterations of hands. Did they get built?

Bernie Roth: Well, the arms was the main – our main thing here was always the kinematics of the arm. And then it became like measured forces on it. So the specialty of this lab here that I've been cooperating for all these years has been force control manipulation. And we always were trying to develop arms that would facilitate that. So there's this whole series of arms that were developed. And I'd say the main thing, the hands, the arms. Other people like Ken Waldron went off to the walking machines, that nature. Trying to think what else. Yeah I don't know I think that's it. I don't know.

Q: What machines were you working with in, say, the '80s?

Bernie Roth: Oh, the '80s, well we mainly had the – the '80s. I forget when Romeo and Juliet came along, that was in – those were just these – what we did is took the arms that we got from Brian, these – do you know what was called the – essentially what – there was the Puma and then there were the replacement arms for those. And we mounted those on moving bases. So that became a series of experiments that way. But we were always developing something. Like with Mike Zinn we tried to develop this thing, which wouldn't hurt people. So if it hit you it wouldn't

hurt you and things like that which would reduce the inertia and those kind of issues. There was always like little gadgets and little things being developed and controlled. Ken Salisbury went off on the PHANTOM and these virtual reality things. Those became very big in the lab then.

Q: How do you feel the work in robotics and kinematics kind of fed each other?

Bernie Roth: Yeah, well I – I think if I hadn't been working in the kinematics of special things, all the stuff of the way we described all that stuff wouldn't have happened the way it did. So I was working in the kinematics, then it seemed obviously the way to describe all these things is to use what we call Denavit and Hartenberg notation. So I've told Jacques Denavit, "I'm the guy who made you famous," because nobody knew about any of that stuff. But it seemed to me the natural nice way to do it. Now you don't have to do it that way. Now it seems like the way to do it. But it was just a natural thing because of the work in kinematics. So it fed very directly into the work in robotics. The work in robotics what – kind of more interested in different kind of mechanisms, and kind of opened up a lot of different areas. So they fed back and forth. The questions of work space and stuff like that. People didn't usually think about that in mechanisms. Now they do. So it's just the nomenclatures, the people going back and forth. So it's – and really it's – we talked about the name robotics. All these things are just mechanisms, really. They're just spatial mechanisms. So it is always what we've been doing, it's just relabeling a lot of it and stuff.

And once you go away from – classical machines just had a one degree of freedom thing and one motor turning something. And you could say that's a mechanism and maybe not a robot. But once you go away from that you start to add more than one degree of freedom and you control with a computer, then is it a mechanism or a robot. You get to choose. So it becomes the same thing, really. So of course they feed on each other. And all the mathematical tools, and all that stuff. So my main interest really was always the tools rather than the specific hardware things. And I felt – applying your same question to the hardware versus the theory, I felt that was a really good marriage. It doesn't work that way so well in other fields, but in robotic or kinematics, whatever you want to call it, it's like perfect because the theory kind of lets you do sort of stuff and all that and then when you build a device it's, "Well, how do I do this?" And, "Hey, that's an interesting question. I never thought to ask myself that question." And so it all sort of came up. So, for example, people started to build manipulators. And then they – six joints. And then someone put a seventh joint on it. And then suddenly you have a redundant manipulator, and what do you do with that extra degree of freedom? How do you use it and stuff? So that brings up a whole bunch of problems. And then this whole idea of once it can move around, there are obstacles. How do you avoid obstacles? So there are all sorts of things, which are kind of always there, but we didn't really – they weren't significant for those specific devices. But then when you get this whole new class of devices, they become interesting. And always in kinematics there multi-degree of freedom devices, but they were sort of a backwater. No one was kind of interested in them. So it kind of made these things, which maybe existed – you can find some

literature on it. They made them much more significant. They put them much more up front. And that kind of worked really well in the robotics, kinematics area. And the controls area, also works really good that way, and dynamics. It was really a fruitful kind of thing.

Q: How much did the influence of cybernetics or artificial intelligence come into your work?

Bernie Roth: Yeah. I don't think it came into anyone's work until maybe recently. It was always this – you know we worked in the AI lab, that's where all this work took place. And there really wasn't any much what I would call AI. Again, what is AI? So, again, it's big fights as to what it means and all that sort of stuff. But basically what their big hits were early on like expert systems and stuff like that, which is not really AI, as they started to talk about it. So just as robotics – the same guys who talked about catching flies and moving all that were talking about all these other fantasy things. And you know they're just hard to come by, and they took a long time. And there's some of that now. And, again, it's a matter of definition. But I would say the influence of real hardcore AI on robotics was very minimal for most of the years. I wish it wasn't that way, but it was just easier to do things the other way and more defined. But people tried, Rod Brooks and swarms and that kind – made the AI stuff and all that. It's useful ideas. I don't know exactly how much of these vacuum cleaners AI has used, maybe use a lot of it, but – certainly in the factories it wasn't the case. But the communities were kind of close, but didn't really talk to each other. But it really wasn't the not talking because everyone was aware. And if there was something that they felt could be used, people would use it. You had a lot of very aggressive people wanting to do stuff. And it just didn't seem appropriate at the time. And things have changed. I don't know. We'll see.

Q: How do you see things changing in robotics? Where do you see it going?

Bernie Roth: Well, there are fads in it. The sort of latest fad is this humanoid robotic kind of thing. That's big. Before that there was the safety things. There's – so they come and go. It's partially funding agencies, it's partially driven by Korea and Japan. They seem to be able to get national projects and all of that. And then they get nervous in the West and in Europe. And they want to catch up, which is kind of good. We help each other that way. But it's so hard to say what catches on and where you go. But there's this thing of fascination, the laboratory and this thing about real things out there at a price that people are willing spend and all that. My own feeling is it's kind of really – the main things is to understand we have robotics. My iPhone is a robotic device. So it just depends how you define it. The computer chip and all those ideas and all that are there. And a lot of it does move mechanical things. So if you have this idea, it's sort of the basic idea of robotics. So it's all around us in every which way, in your car and all that stuff. You know I used to be able to repair my car. I can't do that anymore. It's too robotic. So it's taken over. It's that way. But there's always – I'll tell you the truth. My definition of robotics is the following, it's something you're never going – you're never going to get there. And the

reason – if you look back – I used to love to quote this. If you look back at the Encyclopedia Britannica, they had those before Wikipedia. If you look back something like in 1929 or 30, and you look up something like robo – you’ll find a gyrocompass. And they got this gyrocompass, and they’re talking about it like it’s a robot. Okay? And it was amazing because this was an automatic way to drive a ship, which didn’t exist before. Now, it’s not a robot because it’s old hat. It’s the technology. And so, it’s always this thing that you think people can do and machines can’t do that you attribute to robots. Once the machines can do it, it’s no longer a robot. It’s just what machines do.

So I always – that’s the way I look at it. It’s like a never ending thing. And maybe you’ll get something that walks and does this stuff and call it a robot. But really that’s what it gets down to. It’s just a walking machine. Once it walks, it’s a walking machine. And it just becomes politics and the word. But I think it’s this whole idea of something that only people can do or living things can do and then suddenly a machine can do it. That’s what the robot is. But once it can do it, it loses its uniqueness. So that’s kind of the way I hold it. I’m not going to fight anyone to the death about it. But that’s made more sense to me than anything else. I remember on the other end – it’s so political. I remember – I don’t remember exactly where the meeting was, but there was a meeting. And we were discussing the definition of robotics. This was a high thing we’re going to write it down once and forever. And this one guy who was selling a device, which was – I think it was an arm for a – man-machine thing for nuclear reactors, or something like that. He wanted the definition to be his thing because he wanted to be selling robots, and all that. So I kind of was flippant. I said – he said, “Well, it’s this controllable, changeable thing, all that.” I said – I won’t say his name. I said, “You know it sounds to me like a radio.” I mean if you took the words exactly like controllable, changeable, it was a radio. So it’s – but he meant his device. So if he just abstracted the words of the properties of what the thing does, it could be a lot of things.

So you have some image in your mind of what you’re talking about. And usually when you do that it’s a political game because you have a vested interest in selling or advertising this specific thing. And that’s always been the problem with it, I think. But, you know who cares. It’s fine. You want to call it a robot, that’s fine. But, I think we have them. I think we’re going to have them more. And the world’s going to have more and more automatic devices, and some will interact with people, some won’t, and that’s going to keep going. There was always a kind of hype to it, which is kind of – wish it wasn’t there, but it is. And some is visionary, and some is just airy, and stuff.

Q: Where did you get most of your funding over the years?

Bernie Roth: In my case I was kind of lucky. You know everyone dreams of having a rich uncle or something like that. I don’t really have a rich uncle, but what happened is basically I got my

funding through NSF. And John McCarthy got his stuff from DARPA and all that. And I don't do any military work. So I never took any salary or stuff for that. But the students did and that's their – But at some point there was essentially a phone call and there was a foundation called the Systems Development Foundation. And someone had given them my name as a really good guy. And I was invited to give them a proposal, which was – wasn't competitive – I just wrote down whatever and they bought me a Sun-1 computer, which was the first one I'd seen. And I had money. And I had money to let John Craig write his book and all that sort of stuff. So I had money for a bunch of years, which was just this gift from the gods, basically was foundation.

And then they went out of money. As this thing was set up to go out of business in ten years. And they're the ones who set up the International – the Journal of Robotics Research and all that. It all came out of that foundation. So they helped a lot in the early robotics thing. And then kind of after that I got some more NSF money. So basically NSF has been the – except for this one period of whatever years when this money just came raining down on me, which was kind of nice. And then occasionally companies have been nice to me. People know – they've given me small amounts of money, various companies. But that's kind of where it is. But I've never – I've never done like a huge research operation with a lot – I've always kind of had one or two or three students at a time. And lived with very – I'm a kind of cheap skate. I don't spend a lot of money and stuff like that. I try and stay in cheap hotels, but it's hard with some of my friends. Won't mention any names. <laughs> So yeah it's not been a big issue for me.

Q: How did you get involved with the d.school?

Bernie Roth: Yeah, well it's another – it's a funny – I'm a passive guy minding my own business in the world. So I have a friend Dave Kelley who I kind of was the person who got his promotions to the university, so he thinks of me as understanding how the university works. So when he had this idea of the d.school, he asked me to join the founding group. And the reason was not my great design abilities, but my ability to understand the university and to help with that part of it. So I was part of the founding group and going along it wasn't a big part of my life and all that. And then he got ill. He got cancer. And the dean called me up and he said he would like someone to be an interim director while Dave's getting well. And he asked me to do that. So I started to do that. And I ended up loving it very much. And when Dave got well, he said, "Did you like it?" I said, "Yeah." He says, "Well let's job share," basically. So that's what we're doing. So that's – my life has changed completely now. And I put all my energy and time into this. And build stuff for people who make a dollar a day as opposed to thousands of dollars a day. It's very gratifying. And are these devices robotic? I don't know. I doubt it, but it's a lot of the same principles and stuff.

Q: What kinds of projects have you done in here, recently?

Bernie Roth: Well, we do a lot of stuff here that are amazing. Some of our amazing stories – the most high tech one is –

<break in audio>

Bernie Roth: came up with an app for reading on the iPad, reading – it's called Pulse, reading newspapers. And it was the biggest selling app on the iPad for the first week or two. So these two students sold 26,000 apps at four dollars a shot. And Steve Jobs took his cut, and then they became the second biggest seller on the iPhone. They've just – now they're giving away because they've gotten so – so that's an exciting thing. But more it's things like incubators for premature children that are very inexpensive and totally new way to do it, lighting that's LED driven lighting, curing children with jaundice by just wrapping LEDs around them, making treadmill water pumps for Myanmar, stuff like that. But they've also done stuff for helping Jet Blue get better customer relations. It's all over the place. It's helping VISA – more creative way for people to save, getting Wal-mart – help the employees think that they really are growing green, which they are. No one believes, stuff like – it's all over the place. Just exciting. But they're just kind of – they're more like ideas and just getting things into people's hands and stuff like that. That's a different way to work. I no longer have a private office here. I have a family of twenty people. So it's a different situation, yeah.

Q: Even in the AI lab at least the students are in a very open space.

Bernie Roth: Yeah, the AI is close. It's sort of close, but the ME is not that way. Everyone has their private office. This has some – which are some of the things I liked about the AI lab. We were kind of all there together. I like that set up a lot, yeah.

Q: And when you look back at your career what do you consider to be your biggest accomplishments or breakthroughs or the systems that had the biggest impact?

Bernie Roth: There're like specific little discoveries and all that, which kind of feel good. I'm really proud of the book I wrote. But it's more the human thing, the relationships, the people, those kind of things, the funny stories, the crazy incidents and stuff like that. But there are things that, just being part of them felt really good. And I like teaching a lot so that's been a really nice thing for me. And there are certain things I teach that I do very well at that I never was trained to do. And that's been very successful thing. I do a lot of work on creativity and problem solving and that's been really nice. So I don't know. It's a nice mix of stuff. But there are specific things. There's always a moment when you get the Aha! Paper and all that. And sometimes you write it up and everyone thinks it's fantastic. And sometimes you write it up and no one notices how wonderful it is. But it's very personal, just a feeling of – it's the moment really, for me, at any

rate, that's – you know, you put a lot of energy into stuff and that suddenly that whole snap is kind of very gratifying.

Q: Great. I don't know if we've missed anything that you'd like to share?

Bernie Roth: Yeah, I don't know. I should mention, maybe, that in the early days there was a lot of – it started out with John Craig, there a kind of thing we had going, which was playing tricks on each other in public. And that was kind of a lot of fun. I used to do this thing when I'd give this lecture saying if you don't do – you're going to get a call from god if you do this thing. So John and his buddies arranged to signal that when I said it, suddenly the phone rang in the classroom. Everyone laughed and all that. So then I had to get back at him, and he had to get back at me. And they made movies. And we did all sorts of things. So there was just a lot of fun in terms of – to the job. They kind of – it was a kind of spirit to the place, which isn't around all the time. But those are the old days. Now it's a whole other kind of game.

Q: What ever happened to all the films?

Bernie Roth: We have them. We have the films. We have all the – I actually still have – The AI lab people converted a lot of them to DVDs and stuff like that. If you want any of them, I'm sure Les Ernest has – You know Les, at all? Yeah. Les Ernest is his name. L-E-S E-R-N-E-S-T. Vic is very – you're going to talk to Vic on Sunday? Vic has his phone – Vic sees him all the time. So –

Q: And he has them?

Bernie Roth: I have the original film versions, but he has – I have the original film versions, but Les has, I'm sure, the DVD versions, or he knows where they are.

Q: Have you ever shown them?

Bernie Roth: Not in years and years. So they're around. I actually have DVDs of these jokes we used to play. I have some of those. A lot of the lectures were filmed, you know, we used to – we'd have this thing where we broadcast the classes and stuff. So there was automatic filming going on in the classroom. So we have a lot of that stuff. But yeah see what Les has. He'll have the official AI movies. You ought to get those.

Q: I know it would be great to – if we could add some of those to the collection.

Bernie Roth: Yeah and then we gave a lot of hardware to the computer museum and all that. They have a lot of that stuff. Yeah, so.

Q: Yeah, I've been to the computer museum. It's amazing.

Bernie Roth: Good, okay?

Q: Thank you so much.

Bernie Roth: My pleasure. Thank you.