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Bruce Shimano

An interview conducted by
Peter Asaro

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Q: So, we can just start by having you tell us your name, where you were born, and where you grew up.

Bruce Shimano: Yeah, I'm Bruce Shimano. I was born in Los Angeles, California, grew up there. And I attended Stanford University for both my undergraduate and graduate degrees.

Q: Okay. What did you study as an undergraduate?

Bruce Shimano: I was in the Mechanical Engineering Department as an undergraduate. I was lucky enough that very shortly after getting to Stanford, probably in my sophomore year, I switched to Engineering, and was in Mechanical Engineering. Was randomly assigned to Bernard Roth, as my professor. And he, in fact, was then my advisor, through three years of undergraduate work; and then, my master's work, and my Ph.D.

Q: What did you work on initially, for your master's degree?

Bruce Shimano: I did work in computer graphics. And, so I was at Stanford for five years, getting my bachelor's and my master's, concurrently. And then, I went away for two years. And after that, I called up Bernie Roth, my advisor, again, and asked him what the options were. And he said, "Well, you can come back here, and work on your Ph.D. in Mechanical Engineering." And that's what I did. And he said that he would get me a summer job at the Stanford Artificial Intelligence Center. And he knew people there, and he then got me assigned, got me a job as a research assistant at SAIL, and I was lucky enough to have as my boss there Richard Lou Paul. And so, I went into the Robotics Group. So, I started in robotics, then, when I started my Ph.D.

Q: So, your undergraduate and master's were in Mechanical Engineering?

Bruce Shimano: Both my bachelor's, master's, Ph.D. were all in the Mechanical Engineering Department. At that time, there was no such thing as a Robotics degree. People were either in computers – a lot of them were in computer science. Some people were in mechanical engineering, because of Bernie Roth. A few people, perhaps, in Aero and Astro, because of the controls aspect; but, primarily it was – since there was no official curriculum, at that point – in fact, there were no Robotics textbooks at that point. So, all the work was really done just as a research assistant at the Stanford Artificial Intelligence Lab. And they had a group which was called the Stanford Hand-Eye Group. And, at that time, it was working on the development of the initial electric robots, and programming languages, and controls and such.

Q: So, what year did you join SAIL?

Bruce Shimano: I was at SAIL from '74 to '78 or '9, so about four or five years.

Q: And, prior to that, did you have an interest in robotics, or was it really the opportunity to work in the robotics lab that started you off?

Bruce Shimano: I was always interested in programming and computer science; but I was also interested in mechanical engineering. And, actually, at that time, Stanford didn't have an undergraduate degree in computer science, either. So, as an undergraduate, really, the choices were – I went to Stanford in '67: was there from '67 to '72, to get my master's and bachelor's. So, at that time, your choices were to, as an undergraduate, were to be in Engineering: either mechanical, electrical, or one of the natural sciences – physics, or you could be in math. But, if you wanted to be – and, a lot of the people in computer science, I think, had some relationship to the Math Department, as well. But, there was no undergraduate computer science degree, there was no undergraduate Computer Science Department, and there was no robotics, whatsoever. So, as an undergraduate, then, I was in mechanical engineering, which I enjoyed; although, I've never really been a hardcore mechanical engineer. So, as an undergraduate, I enjoyed the engineering, and I was just lucky enough that I was assigned to Bernard Roth, who happened to be the person in mechanical engineering who did the most work in computer science and programming, analytical types of things. Although, his primary background is a kinematician, he was also the person in the Mechanical Engineering Department who had the most relationship with computers. And, so, I did a computer graphics master's with him as my advisor, because there was a computer graphics group, also.

Q: Who else was in the Robotics Group that you worked with when you first came there?

Bruce Shimano: In '74, when I went back to Stanford, then, to go to the Artificial Intelligence Lab, there were a number of people in the Hand-Eye Group – Richard Lou Paul was my advisor, and my boss and I worked with Lou for many years. And, Lou was a great guy, and he really did a lot of the foundational programming, robot-programming language work. Bernie Roth, who was my advisor: he advised generations of robotics people. Don Piper was one of his students, and Don Piper wrote a sort of a breakthrough Ph.D., which applied kinematics and kinematics series to robots. Don Piper, working for Bernie Roth, is really the guy who established homogeneous transformations, and <inaudible>, and all that sort of stuff. That was all out of Bernie Roth and Don Piper's work. Don Piper left before I got there, but he sort of set a lot of the mathematical foundations for robotics. Lou Paul did a lot of the controls and language work, and I did work with Lou. Victor Scheinman, who was my officemate is the fellow who designed all the mechanical systems and some of the control systems for Stanford, and for MIT. And, so Victor's really the guy who laid all the groundwork for small, electric robots there. There were, at that time, industrial companies like Cincinnati Milacron, who were doing these very large, electric robots for spot-welding. But, Victor's really the guy who developed the small electric robots that would then become the assembly robots in the future. So, Victor Scheinman was my officemate. Tom Binford was more of a vision guy, and he led a portion of the Hand-Eye Group. And Ray Finkel was another officemate of mine. But Ray was mainly interested in kind of language, and not robotics, per se, so he went on to other things. Let's see; I'm trying to think of who else. Bob Bowles did a lot of groundbreaking vision work for robotics, and Bob went on to SRI. I assume he's still at SRI; I haven't talked to Bob for a while. But Bob did a lot of the great initial work in computer vision, as it applies to robotics. He developed a lot of the initial connectivity algorithms. So, Bob was at Stanford when I started there. And there were a number of people who went on to work at the IBM group, in Watson; and then, later on, were spun off as part of IBM's effort to enter into industrial robots.

Q: When was that?

Bruce Shimano: IBM got started in robotics probably around 1980, or so. And, in 1980, there was a sort of boom rush of companies getting into robotics. At the time that Brian Carlisle and I started Adept Technology, after I got my Ph.D., and after I worked for Unimation, we started Adept Technology. When Adept Technology was founded in '83, I believe that there were some 40 to 60 US robot companies. A number of them were in the heavy part of the industry, looking at sort of spot-welding applications, which was the application of the day, and is still the largest automotive application. So, at that time, you had companies like Unimation, which was the first robotics company; Cincinnati Milacron; so, there were companies of that sort that really specialized in the larger robots that were doing spot-welding applications. In the early '80s, there were a number of companies then that entered into the smaller robotics: the assembly markets, and such. IBM was one of them. Westinghouse kind of dabbled in everything; GE. So, there were the large companies, and then there were a lot of start-up companies: Automatix, which Victor Scheinman founded, with a number of other people, like Phil Villers. There were small companies, like American Robotics, Intellidex. So, there was just a wrath of – everybody and his uncle in the United States, in the early '80s, decided to get into robotics, IBM being one of them.

Q: Do you think there was a reason for the interest at that time, something specific?

Bruce Shimano: Yeah, I think that Unimation, who was the first industrial robot company: they struggled for years and years to find a good application, and to make money. In the '70s, finally, there was good acceptance of the large robots for spot-welding. And, today, all spot-welding is done robotically. But, prior to that, people went out there with these big spot-welding guns, and they welded cars together. But, after working for probably 10 or 15 years, Unimation finally had a beach head in automotive and spot-welding, and it's one of those things that you go from having no one believe you, 'til, years later on, it's just the accepted way to do it. So, in the '70s, robotics became the accepted way to spot-weld cars. And, you know, automotive was a huge business, still is. And suddenly, there were all these robots being used for spot-welding. So, people then accepted that, gee, these so-called "industrial" robots: they could really do something. At that time, the things that they did were very simple; they were all teach-and-repeat. You just taught them a fixed pattern, and they did it. In fact, the early industrial robots, like the Unimate, didn't even have computers in them. They had what was called "plated-wire memory," and it was just this, literally, hard-core memory that just played back this repetition of points, and had all this logic; no computers to speak of. That then just took these positions in memory, and just regurgitated them in a fixed pattern.

So, you could, for a spot-welding application, you might teach 50 positions, and the robot would just go: position one, position two; never change anything. It would just go boom, boom, boom, boom. And there would be signals coming in that would tell it, you know, next car was there. And it would just start, and it would just go boom, boom, boom; and it would fire off the spot-welding gun. And the spot-welding gun: what it did is it had fingers that clamped metal together, and it could squeeze the metal. And once the metal was compressed, then it put an electric current through that. And then, that welded the two pieces of metal. So, the car bodies were all done that way. So, there was, in the '70s, finally, an acceptance that these things, which, at that time, were called industrial robots, but which were really dumb, actually could do something. And, in fact, they could do something better than a person could, because they were very repeatable. The cars – in a car, you'd have hundreds of spot-welds; I don't think it was thousands, but you'd have hundreds of spot-welds. Around every door, you'd have sheet metal, and you'd have to spot-weld that thing maybe 20 or 30 times. So, all the various car pieces you were spot-welding together. And robots were very good at that. So, after that time, then, in the late '70s, we started to look at assembly. And suddenly, people thought, "Oh, these robots are pretty good."

And there were some other applications: there was spray-painting, which was popular then, too. But spray-painting was kind of an extension of spot-welding. It was, again, dumb robots that were just kind of doing this very fixed pattern. So, there were spray-painting companies, and there are arc-welding companies. And, in the late '70s, then, there was a lot of interest in assembly and small-parts assembly. And, so that's when a lot of companies got involved. To do a spot-welding robot, they were very expensive robots for the time. They were very big, and you needed a fairly big manufacturing operation to go do that. Once you started talking about electric robots and small robots, then it was a lot easier to break into the market. And there were, at that time, then, the Japanese started coming on board. And the Japanese were prepared to license things. So, for instance, IBM did have their – I think they might have had one mechanical robot of their own. But, primarily, IBM was in the business to sell computers. So, they bought Japanese mechanical systems. And they married them with IBM robots. So, IBM just thought of this as a good application to sell computers. And they thought they had all this computer technology. But there were lots of other companies, too. And everyone just felt that robotics was going to be a big deal, and had these companies like Westinghouse and GE that had always been dabbling in automation. They thought that this was the next big beach head. So, there was this huge boom of companies that got into the market.

It was probably helped somewhat by Automatix, the company that Victor Scheinman started. Victor actually started Vicron, that I worked at. So, Victor, Brian Carlisle, and myself were a part of a company for a few years. Then Victor left that, and went off and started Automatix. And I think Automatix probably helped the business, because they were never a huge financial success, in terms of profitability; but they were a real Wall Street darling, and so they were able to go out and get a lot of money very quickly. And they had a ridiculously high valuation. And they had a lot of business savvy. And people saw that, and they went, "Whoa. Wall Street's interested in this. We can go get a lot of Wall Street money, too." So, there were just a lot of things that happened at that time.

Q: And these companies that you were working with were looking at the same applications in automotive assembly, and painting and welding?

Bruce Shimano: Yeah. At that time, during the late '60s – well, in the '60s, there were a few universities that were involved in robotics in the US. There were a lot of international places, as well. But when you talked about robotics in the '60s, it was really a couple of companies: there was Unimation, who'd been there since the late '50s; Cincinnati Milacron, who was getting involved in stuff like – I believe that ABB might have been there, although I'm not sure. So, there were maybe a couple in Europe, perhaps. And then, in Japan, really, Japanese robots got started when Unimation licensed some of their technology to some of the companies in Japan. So, there were only a handful of companies in the '60s, and really struggling. But there was a lot of robotics instruction going on in the universities. So, there were robotics conferences. And in the '70s, there were lots of conferences. So, in the early '70s, there weren't very many more companies; but there was a lot of university research, and there was a fair amount of government grants at that time. ARPA was giving grants for robotics research, and various other places were giving robotics research grants, looking into both vision and the mechanical side, and the programming side. So, there was a lot of research interest at that time. In the US, it was primarily MIT, Carnegie Mellon, and Stanford. That was, I think, in the early '70s, the primary hubs of where you have quite a few people. There were other places, as well. A little bit later on, Caltech and JPL had some people come out, and such. But, in the early '70s, it was primarily that. But there were universities overseas, as well; there were people who dabbled in robotics in Europe much earlier than that, and some in Japan, as well. And it was in the late '70s that there was this blossoming of industrial interest.

Q: So, what was the first project you worked on when you got to SAIL? Do you remember that?

Bruce Shimano: Yeah. I worked on a language. Stanford was developing a language originally called HAL; but then, of course, there was a problem with "2001." So, we had to drop that, and there was this big fight about what the language should be called. So, finally, we just dropped the "H," and it became AL, just because we couldn’t figure out any better name. And Stanford has – the Artificial Intelligence Lab has a long history of acronyms with no meaning, because at the Artificial Intelligence Lab, the programming language which was used there was SAIL. And people thought it was the Stanford Artificial Intelligence Language, but it never really was. And other documents referred to SAIL, and said that SAIL was really an acronym for a "Suitable Acronym Invented Later." So, Stanford didn't put much credence into what the acronym meant. So, I was assigned to work on AL. And AL was going to be the first high-powered industrial programming language. And I worked there for Lou Paul, who had done the predecessor language, which was called WAVE, W-A-V-E. And WAVE was a very simple system, but it really was a groundbreaking system in that it was all digital, it had trajectory generation, it had kinematics. It had a lot of good stuff in it. So, Lou Paul did WAVE, pretty much by himself, and that was his Ph.D. thesis.

So, in the early '60s, there was sort of the mathematical basis that was laid down by Piper and other people. There was some control work that was done at Stanford, then Lou Paul came along and did WAVE, and pulled it all together into a programming system. And then, when I got there in '74, my job was to work on AL, which was to have all the feature of WAVE, in terms of robot control; but which was supposed to have a full-featured language on top, that you could program in and such. And AL was a very ambitious program, project for the time. And it integrated vision, it had robotic control, it could handle multiple robots. It had a very structured language in it, and it was a very formal language. And we had a group of probably, I think, six to eight of us, working on various aspects. And, at that time, the computers that drove all this stuff were all from Digital Equipment. And they were all PDP-10s, and such. And, so we would have a little – we had a little table about the size of a regular office table that had a robot on it; and then, behind that, you had just this gigantic, air-conditioned room full of computers. And, at that time, the computers were sort of racks and racks and racks of stuff that you used. During the time that I was at Stanford, Digital Equipment came out with their PDP-11 series, which was a computer that could actually fit in one rack. So, we developed our language for that. And then, it was after that that the PC's, and everything else came along. So, computers at that time were actually much bigger than the robots were. So, my job was to work on the language. Victor Scheinman developed the mechanism and some of the controls. So, I was really following in the footsteps of Richard Lou Paul.

Q: So, what were the first robot applications that the software was used for?

Bruce Shimano: Oh, it was all simple assembly applications. But, also, at Stanford, we tended to emphasize vision-based applications. The group was actually called the Hand-Eye Group, within the Stanford Artificial Intelligence Lab. So, we had heavy emphasis on vision, right from the beginning. So, we were working on camera-to-robot calibrations, and things of that sort. So, we did applications like stacking little blocks, little children's wooden blocks. We would try to stack those up, using vision. You'd throw the blocks down in front of the camera, or cameras, and you would identify the blocks. Then you'd pick up the blocks, and try to stack 'em. That's kind of the degree of sophistication that we had at that time. Nowadays, you could do that – no trouble. You could go out and you could get a system, and you'd be able to do that in a short period of time. But at that time, that was a big deal.

We were also working on control algorithms, trying to get the robots to actually perform better because it was – nowadays, robots' controls are pretty well known. You're able to get very good, smooth control of things. At that time, everything was much more crude. And, so really, our projects were very simple projects that we were trying to do: block-stacking, doing peg-in-the-hole kinds of insertions, and really just trying to pull together a complete system. Because at that time, there were no computer-based robots out in industry. Later on, since <inaudible> Milacron would introduce one. But, as I mentioned, in the '60s, all the industrial robots, they were – a lot of them were hydraulic, not electric; and, all of them had very, very simple controls. So, our job was really to have robots that you could program, in a conventional, computer-programming sense; and, figuring out how to integrate that with the vision, getting them all to talk, and such. So, the applications weren't so important as trying to figure out how to get everything to talk together.

Q: So, after you finished at Stanford, where did you go after that?

Bruce Shimano: Victor Scheinman, who did the MIT robot, the Stanford robot – the mechanical design, the electrical design – he was my officemate, and he had a deal with Stanford, where he would support the mechanical systems. But also, he was off, manufacturing, in sort of a garage, mechanical systems that he would then sell to research labs. Because, in the early '70s, there were a number of research people who started getting interested in getting into robotics, but you couldn't take an industrial robot because they were these gigantic things. They were hydraulic, they didn't have computers in them, they didn't have interfaces with computers. So, Victor did a great job at developing an electric robot, tabletop electric robot, a lightweight, in a couple of different configurations. And he then sold it. He went, on sabbatical, to MIT, to go do the MIT, the Scheinman MIT arm. So, he developed a number of these mechanisms. And there were both universities, and also research facilities at companies that wanted to start to do some robotics research, but they didn't want to spend the time to go develop their mechanical systems, which was a big task.

So, Victor started a company called Vicron. So, Victor was simultaneously working at Stanford, at the Eye Lab, and part-time; and also, part-time, still working on his degree, although not very much; and then, working on his company, Vicron. And, initially, Vicron was just selling mechanical robots, and other people had to figure out how to interface them. And then, he decided, well, he'd sell kind of an interfacing package for them. And, to some companies, to some research people, he even sold kits of parts, and they would put it together, themselves. And he sold such things to, like, GM – they had a robotics research group. So, Victor sold a couple of his robots to GM, to GM's research center. And this was probably in '76, I would guess, '76, probably '76, '77. So, Vicron sold a couple of them to GM. And the GM guys – and the lead people there were Mitch Ward and Luther Russell. Mitch came, and he told Victor, well, he was gonna buy a couple of robots, a couple of these mechanical robots, and he'd like to get the controls, also. But, the problem he had was that if there was no software with this thing, then he would take this back to his management and his management looked at this thing sitting on the desk. And for months they'd be saying, “Well, when’s it going to move?” So, Mitch told Victor, “You know, it’d really be helpful if you at least provided us with some test software so that when we got it, we could just plug it in and if we could just move it around a little bit, it would really take the heat off of us. And, you know, the management people would be much happier and then we'd leave them alone and then he can do what he wanted to." So, Victor came to me and he said, gee, he really needed some test software to just move this thing around. It doesn't have to be very elegant, but, you know, he'd pay me some money and since Victor had this deal with the lab, then we talked to the lab and they didn't mind me doing this on their computers. And so, then I worked part time while I was getting my Ph.D. for Victor.

And so, I did this little test program to supply to General Motors. And, it got, you know, bigger and bigger and bigger and so finally, you know, General Motors said, "Well, what is this software?" And, you know, Victor said, "Well, we got to give it a name." And so, Victor called that VAL because there was Hal at Stanford, which had became "Al," which was A-L and so Victor just put a "V" in front of it, just like his company was Vicarm, which, you know, people didn't know whether that was Vic's arm or what. So, Victor put a "V" in front it, in front of A-L and he says, "Well, this is VAL." And so, we wrote a little manual. You know, it was like a four or five page manual. And so, we gave it to GM. Then, eventually, more people wanted that and, you know, I kept on working for Victor. And so, I was doing more and more part time programming for Victor and then eventually building the robots got to be too much for Victor. And so, Victor asked Bernie Roth, my advisor and Victor's advisor, was there anyone that he knew that he could get to help him out. And so, Bernie introduced Victor to Brian Carlisle and he hired Brian Carlisle then as his first full time employee. And so, Brian then started working on the robots and, you know, doing the mechanical design and the electrical design and Brian was actually better at electrical design, you know, had a better background than Victor. Victor is also the primo mechanical guy and a dabbler in electronics. Brian was a good at mechanics, but even stronger than Victor in electronics and I did the software; so it was the three of us.

And so, that's what I did and so when I got my Ph.D. then Victor said, "Well, you should keep on working for us." I said, well, I wanted to move to Los Angeles because that's where my family was and Victor and Brian said, "Well, that's fine with us. We don't see you anyway. You're always at Stanford. You just modem over the software. So, if you want to live in Los Angeles that's fine." And just before I graduated, probably the year before I graduated, Victor sold Vicarm to Unimation and Unimation because the West Coast research division of Unimation. So, Victor and Brian worked for Unimation and when I quit, when I finished my Ph.D. then I worked for Unimation as well. In about '79 or so, the group at General Motors who had purchased a couple of the Vicarm robots, General Motors decided that they really wanted to look at robotics for assembly, which no one, you know, had really done on a big scale. There were people like us at Stanford who were doing these little tinker toy kinds of assembly, but there was no one who had an electric robot who was actually in a factory doing assembly. So, General Motors put out a request for bid for an electric robot that they wanted to use in assembly and that robot was called the PUMA for Programmable Universal something or other. But, they had done a study; GM had done a study and they had arrived at the conclusion that the majority of parts that go into a car after you get it all welded together and everything, they were all small parts and they were, you know, five pounds or less and because they're all assembled by people now, they were all, you know, lightweight and were things that people could get to within an arm reach.

And so, they spec'ed out this PUMA robot as something that could assemble parts five pounds or less and were within sort of an arm's reach. And since General Motors' research lab had purchased one of our robots, one of our Vicarm robots then they obviously had a lot of input into this and so a lot of the spec for kind of the things they wanted were, you know, pretty much what we had developed at Stanford at Vicarm. So, there was this RFQ and lots of people competed for this RFQ. This was a big deal and part of the reason Unimation purchased us was to go after this RFQ, and we won the RFQ. I mean there was, you know, Bendix and Unimation and Cincinnati Milacron; you know, lots of people bid on this thing. All the industrial companies at that time bid on it and we won and we won, you know, in part because they had been using our things for years. So, we got the project to build the PUMA robot, the first industrial all electric computer-driven assembly robot and over the next couple of years that's what we did. We developed the PUMA robot and we delivered the PUMA robot to General Motors. And the PUMA robot and its successors, you know, eventually got to be a big portion of Unimation's business. It grew to be about $30 million or $40 million business for them, you know, in a few years. So, it was a very successful project and General Motors was very happy with it and it really ushered in the computer, you know, true computer-driven assembly robot. There were industrial robots a long time. They were primarily hydraulic. There were electric robots that were introduced for spot welding. That eventually took over all spot welding. Nowadays, there are no hydraulic robots. They're all done by electric ones because the hydraulics, they always seeped a certain amount of fluid everywhere, so they were kind of messy. So, there were other people who developed electric robots. So, we weren't really the first industrial electric robot, but we were the first industrial electric assembly robot. And then after that, you know, everyone tried to get into the game.

Q: Was it mostly just the development done by the three of you, or who else was on this –?

Bruce Shimano: So, it started out with the three of us and then Victor hired a machinist. By the time that we started on the PUMA project, I think our group was maybe ten people or so. So, that's Chuck Spaulding who's still at Dev Technology; Don Allan who's with us at Precise Automation. He did some of the mechanical design. Then we had a couple of other people who were more electronics people. So, I think that Victor, Brian, Chuck Spaulding and I, you know, we were really the robotics people. Dave Pap Rocki who's still at Adept, he was there too and then there were just, you know, a handful of other people who maybe specialized in amplifiers or digital boards and things of that sort.

Q: So, from the time you won the bid from GM until you delivered the prototype, how long did you spend developing?

Bruce Shimano: I think it was about 18 months until we delivered the first prototype and then it was probably another year before we went into production and then probably a couple of years after that before things got smoothed out. In fact, when you interview Brian Carlisle, he can probably tell you about that because we developed this, you know, PUMA robot with – and the control was about, you know, that big. So, we developed this computer-based controller. It had a programming language and had a CRT that you had to type at. It had a little manual control pendant and we did that all in the West Coast and Unimation was in Connecticut, in Danbury. That was the headquarters. So, after we had the prototypes then, you know, we were really a small group. We weren't going to be a production group.

So, after the prototypes, we had to take this back to Danbury and have Danbury start to manufacture it and Brian did that, Brian Carlisle did. When Brian went back to Danbury, and this was in '79-'80 or so; when he went to Danbury, they didn't even have an oscilloscope and they put him in one of the – they had no space for him, so they put him in one of the test bays for the hydraulic robots because these hydraulic robots, they were pretty big. And so, the test bay for a hydraulic robot is about a single car garage kind of size. So, they put Brian in this test bay, set him up and he said, "Well, you know, I need a scope." They said, "Well, we don't have a scope." So, he had to go out and buy a scope. And at that time, they didn't have a computer, you know, in the company and they were about to get their first computer. So, you know, everything was still ledgers and paper and pencil. And so, they didn't even have a computer in the building. And so, you know, that's what Brian dropped into and then we had to transfer our technology to them, you know, people who had never seen a scope and who never touched a computer. So, that was – and Unimation was, you know, one of the better companies and so that was a real rude awakening and it took a lot of time for Unimation to come up to speed and understand that.

They went out and they hired some good people to take all this stuff over from us and, you know, they did a good job, but it was a real cultural shift for them. There was a lot naysayers and people who didn't support us back in the corporate headquarters because there were people there who, frankly, didn't even think that electric robots were a good idea. They said hydraulic robots are really the way to go, and there are – you know, there is some reason for them to think that because hydraulic robots are very efficient in terms of energy. So, they're very efficient, but no matter what you did to them, you just couldn't get them to stop leaking oil, hydraulic fluid. And their servos were very hard to control and such and they were expensive too because they had these very expensive valves. Hydraulics at that time were mostly things that people had these sort of bang-bang controls that you just opened up a hydraulic valve and the hydraulic fluid rushed in and, you know, some big plow or something would do something. To really do robotics with hydraulics, you had to have these very expensive aerospace valves to control them. So, it was expensive to do it, but there were still people at Unimation who thought that hydraulics were the way to go and they resisted electrics for the longest time. And if it hadn't been for GM insisting on an electric robot, you know, Unimation would have gone down with hydraulics, you know, forever. So, it was a big shift.

Q: That's fantastic. I can't think of the next question; too many questions to ask.

Bruce Shimano: Well, I can tell you about the '80s. How about the '80s?

Q: How about the '80s and what would have been the first year that GM was actually using a PUMA to manufacture cars?

Bruce Shimano: You know, I don't know for sure, but I would guess they probably started using them around – you know, prototype probably about 1980, '81 at the latest and so that's when they started, you know, putting them into the factories. And then, of course, we did a small five kilogram one and then there was sort of a larger one and a larger one that came along and Unimation did those. After we got the – well, actually, sort of concurrent with doing the PUMA, we were still all, you know, very much fanatics about machine vision with our background at Stanford. And so, even though GM was not interested to begin with, you know, we did the first vision integration with industrial robots, showing an industrial robot working with vision. Now, I think that was at – we did our first demo of that at Robots 9 or something like that in Washington. I believe that was around '78 or '79 we did the first one.

Q: That was at an annual robotics conference?

Bruce Shimano: Yeah, yeah.

Q: And who sponsored that, or how was that organized?

Bruce Shimano: It was RA and also there was the International Robotics Group. So, that was a big industrial robot show. And so, you know, we were always, you know, very enthusiastic about computer vision. And so, we did, you know, the first integration of the computer vision systems that were coming along at that time. There were people out of – SRI did the first sort of practical vision that you could use with the robot. They did blob analysis and connectivity. Before that, you know, people were just sort of flaying around, trying to figure out how to identify objects and SRI came up with blob analysis and connectivity and they said, "Look, if you just do a binary image and if you find the edges, the bounding edges and if you then characterize that blob by the center area and then its moments of inertia then that tells you a lot. And so as long as the parts aren't touching and so long as they're well lit, you could actually go out and pick up these parts." So, SRI developed connectivity, which was, you know, a great thing; not the end all/be all, but a huge step forward. Out of SRI came a company called Machine Intelligence. They were started by Charlie Rosen and some other people.

And so, Machine Intelligence was going to take the – they got a license from SRI to productize this. And so, we took one of the Machine Intelligence systems and we interfaced that to one of our robots and we showed that Robots 9. There were vision systems before that, but the vision systems were all simple inspection systems. They would look for a dark patch or a light patch, or they would count pixels or they would look for an edge and things of that sort, which is fine for inspection. So, there were vision inspection systems, you know, during the '70s and maybe before, but what SRI did is they came out with the first object recognition system that could tell you, "Here's where this object is," you know, that you would do simple teaching and you would say, "I've got this round, you know, cap I want to pick up" and then it would go and tell you, "Here's the cap. Here's the cap. Here's the cap" and we go, "Boom, boom, boom, you can go pick them up."

Q: What was that program called?

Bruce Shimano: I don't know what their program was called, but their technology was called blob analysis and now people call it connectivity. And the company was Machine Intelligence and Machine Intelligence, after they got started then Phil Villers and Victor – so, Victor was with us until, I think, 1980 or so, maybe '81 and then he went back to Stanford for a short time. And then, he had a long-time friend named Phil Villers. So, Phil Villers had quite a bit of money. He had a cab company, but he left that and so, Phil Villers was looking around for something. And so, Phil talked to Victor and they pulled together the company that they eventually founded, which was called Automatix. And Automatix, as I said, you know, did a great service to the robotics industry by, you know, really attracting financial people into the business. Automatix took the same SRI technology and that was one of their first products as well.

Q: So, how did robotics unfold in the '80s after that?

Bruce Shimano: So, what happened was that for Brian – so, Brian, Victor and I did the PUMA. We delivered the PUMA, but after that, Victor went back to Stanford and so Brian took over management of the group. You know, we slowly grew and so there were probably about 20 of us or 25 of us at Unimation's West Coast group and we were still doing development. Unimation was owned by another company and that company – Unimation was starting to do better and I think they might have hit $70 million in revenue. I don't know if they ever hit $100 million in revenue, but Unimation was growing, was doing better. Robotics was very popular. Conduct who owned Unimation got into financial trouble and Conduct, in addition to selling off their corporate headquarters, they sold off Unimation. And so, Unimation was sold to Westinghouse. And so, as part of this, you know, big spree of robotics in the early '80s, with everyone getting into the business – Westinghouse already had a robotics group, but they looked at Unimation and they said, "Well, if we bought Unimation then we'd really get a lead up on everybody." And so, Unimation was sold to Westinghouse in – I think it closed in December of '82. And Westinghouse, the Westinghouse people were very good people and they were nice guys to work with, but this whole robotics thing was a total disaster and the group that originally justified buying Unimation, well, they were purged before the sale closed and a new team was put in place right after the sale. And then, that team was purged because Westinghouse was really struggling with some other businesses, and so, they were reorganizing like crazy.

So, between the time that they decided to buy Unimation and, you know, the deal closed and a few months after that, there was like the third management group that was put in charge of Unimation. They were good guys, but they had no idea why Westinghouse purchased Unimation and, you know, what the business was all about and they had no background in robotics. They then toured, the new management then toured the various things that they had bought and they came out to the West Coast and the fellow there was a very nice guy. He was the vice president of research and development at Westinghouse. He was in charge of the 3,000-person Westinghouse lab in Pittsburgh and he knew nothing about robotics. And he came out and he said, "I don't know what we're going to do with Unimation, so I have no idea what to do with the 25 of you guys." And he says, "You know, maybe you guys ought to all move out to Pittsburgh and, you know, join this 3,000-person research lab," and he invited us out. And we went out there and, you know, they had smart guys, but, you know, we started as a three-man company and then we got to be ten people, and then we were sucked up by Unimation which was a few hundred people and we thought that was pretty big and then suddenly we're in Westinghouse that's got 3,000 employees or something of that sort and they're inviting us to, you know, join their 3,000-person lab. The Stanford Artificial Intelligence lab was probably 50 people or something like that.

And so, we went there and they were really nice guys and they said, "Well, you know, Westinghouse knows who we are and if you'd like to be with us, fine. If you don't, you know, you don't." And so, we went to Joe Engelberger, who was, you know, the father of robotics and the head of Unimation and our boss during the time we were at Unimation and we said, "Joe, you know, this just isn't for us and, you know, we're going to leave, Brian and I. We're going to leave." Joe said, "Well, don't leave. You know, what are these other 23 people going to do out there without the two of you guys since you, you know, run the place?" He said, "Let me talk to people at Westinghouse." So, he talked to Westinghouse and one time when Brian and I were out there, because now what happens is Westinghouse, since they really had no clue what to do with Unimation then they did what a lot of big companies did. They hired MacKenzie to come in and do a market study for them and tell them what to do with this thing they just bought. So, MacKenzie was running these market studies and as part of the market study, they put together these little focus groups. And so, Brian and I had to attend meetings in Pittsburgh in this focus group to help Westinghouse decide what they were going to do. After one focus group, the vice president of research invited us to his office on the, you know, 23rd floor of the Westinghouse building and he said, "Well, I hear you guys want to leave" and we said, "Yeah, you know, it's not for us." And he says, "I understand that entirely." And he says, "Coincidentally, Westinghouse has just done a study and we've decided that –" because big companies, in that day, didn't have the option of going belly up, that they owed it to people; you know, it's kind of a different mentality than the last couple of years that's happened in the U.S., but he said, "You know, Westinghouse doesn't have the luxury of going bell up. We got a lot of people here and we have a lot of shareholders and that means that we can't take risk, but we want to innovate. And so, we decided the only way we can innovate is that we've got invest in small things."

And so, he said that this ruling just came out, that Westinghouse said they were going to go invest in startups and he said that they were thinking about buying into things. They never thought of spinning us off, but he said, “Why don’t you two guys, rather than just going, why don’t you take the West Coast with you and take these 25 people with you,” and he said, “You can take the technology you’ve developed. You can take the people you’ve developed and all we want is we want just a minority ownership in it so that we can keep track of you guys and at some point, you know, we may decide that if you guys are interested, you know, we might buy you back, but it would be our way to invest in innovation.” And he said, “You know, you have to go get money yourself,” which was no problem because there were lots of people that we knew, and he said, “But you can take the people, you can take the facilities and the only restriction is you can’t go do a knock-off PUMA because you did the PUMA for us and that’s ours. But so long as you don’t do a PUMA, you can do whatever you want. You can do whatever you want with the technology. We don’t care.” We were stunned because here it was, we thought it was going to be a contentious battle and we thought they were going to argue with us and they just tell us to take the thing.

In fact, Brian and I left the office, we drove to the airport to catch a plane, and halfway to the airport, we just couldn’t believe it. So, we stopped at a phone booth and we called his second in command who was at the meeting. We said, “Did he just tell us that we could take that and we have the technology and we can do what we want and we got the people?” And the guy says, “Yeah.” He doesn’t believe it either, but that’s what he said and that’s how we started that technology. So, we got venture capital money and Westinghouse stayed on our board for, you know, probably 15 years until we went public. Westinghouse participated in the various rounds of financing, you know, keeping their pro rata share to keep their ownership the same. They had a board member and they would send people out. And so, we had a good relationship with them, but that’s how we started Adept. And so, we started Adept in ‘83 when there were 50 other U.S. companies in robotics and clearly, we were going to be in assembly robots and although we were 6-axis kinds of people, we couldn’t go do another PUMA. And so, we looked around and we said, well, we’ve been doing work in direct drive technology and we really thought that there was good work, you know, research being done in direct drive. So, we thought direct drive was the way to go and there was a lot of interest at that time in SCARA robots because SCARAs were just becoming popular. The PUMA was a 5-axis or 6-axis robot.

In fact, a couple of years after that, the Japanese had invested the SCARA and the SCARA seemed to be a really good assembly architecture. We said, gee, we’ve got this direct drive motor technology that we’ve been working on and the Japanese have introduced this SCARA configuration, which seems a very good configuration because it’s cheaper, because it’s only 4-axes and the thing that the Japanese discovered was that a lot of assembly is vertical assembly. So, it’s parts that go vertically into other parts. And so, the PUMA was modeled after a person and so General Motors wanted this articulated robot with six-degrees of freedom, that could reach around and do all these things, which a PUMA could do. But, it turns out that for assembly, most assembly is vertical assembly and you only need four-degrees of freedom.

Furthermore, you know, having the compliance of the SCARA going horizontally, you know, people thought that would be a good idea, although that never really turned out to be very much. The key idea was that assembly is really a vertical operation. And so, we said, you know, the Japanese researchers, they've hit on something here. And so, we went out and we did the Adept 1, which is a direct drive SCARA robot and that's what we introduced. SCARA robots were Adept Technology's claim to fame. And so, we competed with all these other 40 U.S. robot companies and some of them were using articulated configurations that were a lot more expensive. Some of them were using Japanese robots. Some of them did some of these cheap knock-offs and we were lucky. We just had, you know, a great team with us in terms of the sales and marketing people and the manufacturing team and the engineering team. There was really no one who had a better engineering team than we did. And so, we put together the Adept 1 and that was really, you know, the key product for Adept for probably 15 years.

Q: That was Lou Paul?

Bruce Shimano: Lou Paul. Richard Lou Paul.

Q: Oh, Richard.

Bruce Shimano: All of us knew him as Lou Paul, but, in fact, Richard is his first name.

Q: Okay.

Bruce Shimano: But you definitely need to speak to Victor Scheinman, because Victor's the guy who invented all the mechanical systems that everything else sprang from. And I think you should talk to Bernie Roth too, because Bernie is the guy who, he's really the person who got everyone interested in robotics at Stanford and was everyone's advisor. He was Don Piper's advisor, Mike Kahn's advisor. He was Richard Lou Paul's advisor. He was Victor's advisor, Brian's advisor, my advisor. He was everybody's advisor at Stanford.

Q: And he's still in the Stanford?

Bruce Shimano: He's still at Stanford in mechanical engineering.

Q: I'll have to check our schedule.

Bruce Shimano: Yeah.

Q: Doing 20 of these in the next two weeks.

Bruce Shimano: Yeah. If you want to, tell the question of if you want the early years or the sort of later years. And if you want the early years, you should speak to Victor and Bernie and possibly Lou.

Q: Yeah. Okay. So the Adept 1. So what year did you finish that and it was?

Bruce Shimano: So we founded Adept in '83 and we demonstrated the Adept 1, I believe it was June of '85. And we went to production shortly thereafter. And the interesting thing about the Adept 1 is that when we started Adept people still questioned whether vision was at all useful with robots. So it'd taken people 1960s to really think that these things which were called industro robots were useful at all. And then in the '70s there was an acceptance that you could use industrial robots for blind spot welding, for spray painting and things of that sort. And then in the '80s, people began to accept that you could use electric robots for assembly. But when we started Adept, still people didn't think that computer vision was very useful. And there weren't any good vision applications.

Q: What kind of cameras were they using? What kind of video signal were they?

Bruce Shimano: Cameras at that time in the – well, way back in the '70s there was these cameras that were Koho cameras that were these boxes about like this. In the late '70s then the cameras were kind of these cylinders about this big. And their prices were better, but they were, the resolutions, were probably 100 by 100 pixels or something of that sort. Nothing. And then actually, gradually, they got to be 200 by 200 pixels and things of that sort. So there was a lot of advancements in cameras during that time. So digital cameras really came a long way in the late '70s, early '80s. But there still were not any good robot vision applications. And almost all robots were black. Were just blind pick and plays. And as I mentioned, we demonstrated a vision application in the late '70s, but still was simple.

So as I mentioned, there were a couple companies that came along out of the SRI technology. Machine Intelligence, who tried to sell it, but really they were still selling more inspectual things. They never really got a good foothold in the robotics. And then Automatics, they were going to push vision big time. And they sold some vision, but really not very much. They initially came out with a vision system, but most of their stuff was just blind work too. And we had sold a few vision systems here or there, but we were convinced that vision was a good thing. And it's interesting that the very first Adept 1 that we sold, Adept 1, number 1, that had a vision system on it. And we didn't know why. <laughs> And probably six months or a year after, we were still asking, "Why are these people buying these things?" <laughs> And through a good part of the '80s, robot companies everywhere didn't sell vision. We sold vision from the beginning of Adept. But there were a lot of companies that never offered vision through the '80s, robot companies. So we were still looking around for an application. People were still buying vision. We didn't know why they were buying vision. Adept from the very first year, we sold 25 percent of our robots with vision and didn't know why. We had a very smart marketing lady by the name of Elaine Wood at Adept. And so we asked Elaine, "Go figure out why people are buying vision," <laughs> "and try to figure out how we could use vision, because we think it's a great thing." But we got to figure out what we can do with this. And of course, there were companies like Cognex who were selling vision for inspection. There were specialized companies in the semiconductor industry that were starting to look at vision.

But so Elaine went around and she said, "The great thing –" we're starting to, at that time, probably in '86, '87, we started to look at assembling of printed circuit boards. Because there were a lot of these really expensive chip shooters. And these chip shooters, they were these hard animation things where you put on reels of components and they would just go boom, boom, boom, and they would stuff these things down. Through-hole components at that time, very little surface map. And so there were these very expensive hard animation machines that people made for through-hole insertion, that did the lead prep and stuffed these things down and such. But Elaine said there's a lot of components that fit into the odd component category, and by that it's not resistors and capacitors that you can stuff down. There are these, they might be an oscillator or a power supply or something you got to put down. There might be one or two of these things on a board and they're really big and they're done by hand now. And Elaine said, "Wouldn't it be great if we could use a robot to put down these odd components and vision would be tremendous, because you have to look at these fiducial marks on these boards and these fiducial marks or these landmarks will tell you where to put the chips down. And these boards kind of move around a little bit and they're all through-hole components, and so you got to get these leads through these holes. And if you try to do it blindly, that's just never going to work."

And so she said we ought to develop an application to go find these fiducials and then adjust the robot position, put these things down, odd components down. And we did that and that was the first application that we did where we really knew what we were doing and we really knew what the benefit vision was. And nowadays, all these chip shooters, they all use vision too. But at that time, they didn't. And people use vision for mask alignment and things of that sort, but they didn't really use it for putting down chips.

Q: So what year did you finish that?

Bruce Shimano: That was probably I think '86 or '87, that sort of time frame. And so that was really when we knew why we were selling vision. We were promoting vision since the late '70s. The very first robot went out with vision, but finally <laughs> two or three years later, we finally knew why we were selling vision and what it was good for and applications that we can go out and tell people, "Hey, if you're going to go do this, you really want to use vision, because here's what it's going to go do for you."

Q: Yeah.

Bruce Shimano: So the ‘80s were a sort of consolidation time. That’s when a lot of U.S. companies went by the boards. And so we went from 50 industrial companies down to a handful and by the ‘90s, Adept was the only U.S. robot company left.

Q: Wow. What was the last handful?

Bruce Shimano: Well, there’s General Motors started it about the same time. They, General Motors, decided that in ’83, about the same time we were starting, about ’83, ’84, that they weren’t getting what they needed from the robot venders and they were going to start their own robot company, which was General Motors FANUC. And so it was a partnership between General Motors and FANUC. And FANUC would be doing the manufacturing. General Motors would do the controls and be the marketing arm. General Motors FANUC was, I’m forgetting, but I think in the late ‘80s FANUC bought out General Motor and so today they’re just FANUC. Let’s see. Who else was – gee, I can’t even tell you who the last ones were. There was just a bloodbath of them going out of business, and that’s when the Japanese were coming on strong. And the Japanese, as I mentioned, they originally got their technology by licensing from Unimation.

Q: So what were the big Japanese companies at that time?

Bruce Shimano: Well, FANUC was big. SECO instruments, in terms of assembly. Sony was in there and still is in there.

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Bruce Shimano: I'm forgetting some of the other big ones. It's just escaping my attention at this point. And of course at that time, then you had ABB was really doing well. Kuka, you know, both really a focus on automotive. So, there were a number of European companies.

Q: So, when did Kuka start?

Bruce Shimano: I couldn't tell you. Yeah.

Q: Okay. So, then Adept was the last U.S. company standing in the early '90s?

Bruce Shimano: Right.

Q: And what happened since then?

Bruce Shimano: Brian and I ran Adept. And we were the two founders of Adept. He was the CEO, and I was on the board of directors, the vice president of research and development and ran engineering from time to time. But he and I ran Adept, and we finally were able to take it public in '96. So, 13 years after we started it, I think we started making modest profits probably in the late '80s. And so, during the early '90s we were making modest profits. Our profitability got a little bit better the mid '90s, and so we took the company public in '96. In the late '90s, you know, once we were a public company, then there was more pressure than ever to make profits. And the board really wanted to see us expand the company quite a bit and to take some risks. And so, we made a number of investments, strategic investments in semiconductor, and then also we started to make some head way in semiconductor, in the packaging markets, which we did pretty well at. But they wanted something a little, you know, that was really going to explode. And so, in the early 2000s, we invested in photonics in a big way. And after the Internet bust, then in the early 2000s, people said, "Well, you know, the Internets, all these startups are sort of going bust." Because clearly the Internet's going to work, but in order for the Internet to do better, you know, people need more bandwidth. And so, it was thought that the next big push was really to get bandwidth in everybody's house. And the way to do that was through fiberoptics. And so, photonics was the development of fiberoptics, that you can lay this cable everywhere and get bandwidth.

And so, in the early 2000, this was this huge rush to photonics, and everyone was going into photonics. In fact, Corning, you know, had been in optics for a long time. Corning had Corningware; Corning had Corning missiles and things of that sort. And you know, Corning in the early 2000s, they sold off Corning ware, and they sold off the missile division, and they were going to specialize just in photonics and fiberoptics, to lay cable. And then there were lots of other companies, like J.D.S. Uniphase and such. And so, you know, photonics just took off. And we said this is some place that we could play. Because we had actually been working with Corning on doing optical assembly for a long time. So, we made a big play in photonics. And photonics was this rush, you know, just like the Internet and everything else was. I mean, it just exploded. There were conferences and, you know, money everywhere. And then it just cratered. <laughs> And unfortunately, that's where we made our bet. And then, of course, towards just about the time photonics was cratering, then 9/11 happened. And so, what happened then was that, you know, the combination of 9/11 and just the cratering of photonics, we had to really shrink Adept. We grew Adept. I think we peaked out over a hundred million dollars in revenue. But suddenly, you know, with 9/11 and photonics cratering, we had to shrink the company by – you know, get rid of two thirds of the company. And that was very painful.

So, we shrunk the company down from a hundred million dollar revenue down to about 30 or 40 million dollar revenue. And unfortunately, you know, with it all the people. Some of them, you know, had been with us a long time, all of them friends. And so, we made it through there just by the skin of our teeth. And so, you know, we were still alive. We made it through to another crunch, but we needed more cash. And so we went out and we got more cash. And the board said, well, they want to change management, that we had been running the company for 20 years, from '83 to 2003. And they said that that was long enough, that, you know, most companies change management all the time. And for us to be in charge for 20 years they thought was way overdue that they got new management in a public company. And so, as part of getting the money in, we got shoved out, which was okay, because it was a very unpleasant time for us. It was really sad to part with a lot of the friends that we had, but it was a very contentious situation at that time with the board of directors. And Enron had happened, and basically it's not very fun to run a public company in any vein. And Adept, even though we had a good industry and then though it was a fun industry, being a public company is just no fun. So, that's when we left, in 2003, and we started Precise Automation, Brian and I.

Q: Okay. So, and what's the focus for Precise Automation?

Bruce Shimano: Our focus is different, that when we started Adept, we knew we were going to be a big company. And so, right off the bat, we got tons of venture capital funding. And we put in a whole manufacturing operation and we grew like crazy in the early years. And so, our goal was to be, you know, a big company. With Precise Automation, our goal is to be a small company that really focuses on technology, and instead of investing in a big sales channel and a big manufacturing organization, our view is that, you know, those days are kind of done. And so, we have a very small sales force, just a couple of people, and we have no operations to speak of, and we have partners who do all the operations for us. And so, in fact, we're at Chad today, and Chad does all the robot manufacturing for Precise Automation. So, Brian and I are still, you know, robotics, industrial robots is our business. And controls and robots is our business, but we now feel that it's better to have the flexibility to have other organizations within the United States, you know, do the manufacturing. So, we still have, you know, all our products manufactured in the U.S., but we just don't do it ourselves. And we focus really on the technology.

And also, at Adept, we've shied away from automotive, but we did a lot of electronics. And at Precise, we're really focused on other marketplaces, lab automation, we do a great deal in will be automation, and our robots are now designed for that. We do some work in semiconductors still. We do a little bit of packaging and such. So, you know, we believe that there are just different marketplaces now and different ways to do business. And so, you know, obviously automotive is still a big portion of the industrial robot business, but it's a commodity business, and it's pretty brutal. And it's just, you know, these large automotive companies just are beating the robotics people to a pulp in terms of making ends meet. But, you know, there are a lot of robots that are still sold there. Semiconductor is an interesting opportunity. There are actually more robots sold in the semiconductor, I think, than there are to automotive nowadays, but it's a very small market in terms of the number of players and the number of users. So, we supply controls in the semiconductor.

We think lab automation, pharmaceuticals, is a really interesting area, though, because people in that business are getting to the point now that they're handling more and more product.

We have one company that we deal with, and their business is to handle the blood samples that, you know, you go and, nowadays, everyone when they get a physical or you go to, you can go your doctor, you get blood workup. And so, there are thousands of tubes of blood that have to be sampled, tested every single day. Well, more and more, you know, the day was when you'd go to your local doctor and they would do their own blood work. Well, people don't do their blood work anymore. They send them out. And so, now there are these companies, and their whole job is to do blood work. And they will get in 70 thousand vials at night, and by the next morning, they have had to split those out into all these tests and return the results to the doctors. And so, there are these huge blood processing places. And it's all done by hand. You know, 70 thousand tubes come in and people, you know, pour it out and, you know, split it out into various tests, then load that stuff in. And I've not toured one of those plants, but, you know, these customer of ours have toured it, and they say if you'd see these plants, you would never believe test results again in your life. <laughs> Because the number of mistakes that are made in all that handling, they said, is just frightening.

And so now those companies want to automate that. They've had these little plastic tubes, and they want to, you know, have robots power out those tubes into these samples. Then they want to load these samples into these testers, but they need to handle 70 thousand in a night. And so, there are these huge automation systems that they're putting in for that. There are other people who are doing, you know, all sorts of pharmaceutical tests and such. And you know, pharmacy is just a huge business now. And all this pharmacy, it's all a matter of testing. You know, these people, and they're developing new drugs, it's all testing. They split them up, they, you know, try various things, and it's a tremendous amount of testing. And all that testing used to be done by hand, but now more and more they're automating that. So, you know, we believe that lab automation is really a very good industry.

Q: Are you involved at all in the genetic sequencing machine?

Bruce Shimano: Yeah. They do that as, you know, they do that as well. So, yes, that's part of that industry. So, you know, there are a lot of these areas that, you know, there are the areas that people think of, like electronics, which robots are used in quite a bit. There's automotive that robots are used in. Spot welding, there's even arc welding that people use robots in. But, there are all these industries that are kind of under the radar that use thousands of robots that you don't think about. Semiconductor's a good case, you know. People never even paid attention to semiconductor, and yet there are thousands of robots sold every year into semiconductor by just a few companies.

Q: So, what are the big companies now for industrial automation in semiconductors?

Bruce Shimano: Well, in semiconductor, it's mostly the Japanese. You've got, you know, I believe that Yoshikawa made a big push, and so Yoshikawa's got a lot of semiconductor business. They might be the biggest semiconductor robot of the conventional robot people. The company that specializes just in semiconductor, though, is Brooks. And so, Brooks is not thought of as a robotics company, but in fact, that's what they are. They're a robotics company, but they specialize just in semiconductor. And I think probably Brooks and Yoshikawa I would guess would be the two biggest suppliers of semiconductor robots. And then there are lots of other smaller players.

Q: And what about in laboratory automation?

Bruce Shimano: Yeah. That's just an emerging area now. And so, there are some small ones. Actually, there is one company that does Cartesian robots. All they do are Cartesian robots, and all they do is for a small segment of lab automation. They do this Cartesian robot which is just to – and I'm forgetting what their particular application is – but they sell about a thousand robots a year, which, you know, is probably more robots than a lot of robot companies sell. And no one knows about them. You know, and they make this one Cartesian system that they sell a thousand robots a year, and that's all they do. And they're a Swiss company, and they just make, you know, this little robot and accessories. And they do probably, you know, some tens of millions of dollars in revenue. But they're not, you know, they're not part of any robotics organization. They don't show up at robotics shows. They just attend these lab automation shows.

Q: What about packaging?

Bruce Shimano: Packaging, you know, I think that ABB does a lot of packaging. Adept does a fair amount of packaging. I don't think that FANUC or Yoshikawa has ever broken very much into packaging. They've tried. And then, of course, you know, there are specialized robots. For instance, there's the Delta robot, which SIG makes. And, you know, the Delta robots, there's been a real up surge in Delta robots because all the patents ran out a year and a half ago. And so, Demaurex held the original patents for the Delta robots. And they sold a license for the larger Delta to ABB, and they sold the patent to the medium size robots to SIG. And so that's why the Delta robot has only been used by – only been sold by Demaurex, ABB and SIG for the last 15 years. But the patents have all run out. And so, that's why in the last year and a half, you've seen Delta robots spring up everywhere.

Q: What's a Delta robot?

Bruce Shimano: Delta robot is – it's a parallel robot. It looks like if you take your camera tripod, flip it upside down, that's a Delta robot. And so, instead of a serial robot where you have one link after another link and then the end is moved by this serial chain, the Delta robot's a parallel robot that has these three legs. And by driving these legs up and down, you can move this platform around, and then that platform, it's a very clever design because by the arrangement of these links, the platform always stays horizontal. So, it's a very clever design. It has the attribute that all the motors are stationary. Because in any robot, a lot of the weight is the motor, and where you put the motors. And so, you have a choice. You can either put the motors close, in which case you've got all this weight out there that you're trying to move, or you can remote the motors, in which case you've got some sort of drive train, which is causing you a lot of money. Well, the Delta robot is this parallel system. <phone alert/talking>

Q: Okay. Let me think if there's other questions. So, anything else you want to say about the '80s or '90s that we didn't cover?

Bruce Shimano: No. You know, I think if you talk to the Japanese and some of the other people, you will get more of a sense for people who are trying to break into the service industries and such. And we just haven't, you know, that's just not been our forte. But that's, service robots have been, you know, important things since the mid '80s, but they just haven't gone anywhere.

Q: What about consumer robots?

Bruce Shimano: No. They're mostly toys. <phone ringing> The things that there have been is that there have been various educational robots that people have made from time to time, but there really hasn't been a very popular educational robot that's lasted, you know, more than a few years. So, there have been a number of people who have tried education robots, but, you know, none of them have made it. Yeah, I think that's about it. Also, when you talk to – you know, there's a big distinction between robotics and what we do. I think that people have correctly characterized that we're really in intelligent automation. And they would differentiate that from robotics, which, you know, is going towards more autonomy kinds of things. I mean, our goal is not to have thinking machines. Our goal is to have things that are cost effective and that are easy to teach what to do. So, I think that there is still just a, you know, a huge gap between autonomy and thinking machines and what we sell.

Q: A lot of the technologies you've developed could be used for all sorts of applications.

Bruce Shimano: Right.

Q: So, what do you think the biggest innovations that you personally came up with in your career are, or the people you worked with?

Bruce Shimano: Well, I think we were a good promoter of vision for robotics for a long time. You know, I suppose things would have been different if we would have been a flop at General Motors, you know. If someone else had gotten the bid there and had really screwed that up, that probably, you know, wouldn't have changed things forever, but it probably would have slowed things down considerably. Because the Puma really was a landmark machine, and it was a very successful machine both from a product point of view and a, you know, commercial success. And in fact, the last time that I saw Jawa (Joseph) Engelberger and Victor was when, you know, one of the first Pumas was inducted into the Smithsonian. So, I think the Puma was really a big deal. You know, and that was a bunch of us who worked on that, and that, I think, was very important to get <inaudible> electric assembly robots, you know, accepted. And if we had blown that, probably it would have delayed, you know, their acceptance by some number of years. Yeah, we've done okay in the software. I think, you know, we've continued to advance the software, but from a very pragmatic point of view. You know, I'm not sure that at its core, I don't think that there are things that we do today that are all that different from the language we wrote back in the '70s. But it's just that it's so much more accessible now.

Q: Okay. Thanks.

Bruce Shimano: Okay.

Q: Appreciate it.