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Hirochika Inoue

An interview conducted by
Selma Šabanović
with
Matthew R. Francisco

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Hirochika Inoue: Konichiwa.

Q: Konichiwa. If we could start with you telling us your name and where you born and when?

Hirochika Inoue: My name is Hirochika Inoue, I was born in 1942, the Kawashima City, southern part of Japan.

Q: What was your family like and where did you go to school early on?

Hirochika Inoue: Pardon me?

Q: What was your family like and where did you go to school early on?

Hirochika Inoue: I don't understand what the...

Q: So, family and then school, what kind of school did you go to?

Hirochika Inoue: Mine?

Q: Yes.

Hirochika Inoue: My family is not special. They're very old family. School, that is for, so university is okay? Just only the university?

Q: I mean, you can tell what kinds of things you were interested in as a younger person as well.

Hirochika Inoue: Ah, yes, I see. Since my childhood, I like to build something for model airplane or radio and so on. And therefore, I like to go to the university particularly for engineering or technology. And so, I chose University of Tokyo and going to the faculty of the engineering and when I choose my majors, I am thinking about "Shall I go to mechanical engineering, or electrical engineering?" So, that is a very good time and when I'm entering into university, that is 1961, so the automobile is now going and also the electronics is emerging. So therefore, I'm wondering which is good for me? But, I like really to make something that moves, therefore I chose mechanical engineering. But I love electronics too much. And therefore, when I decided to go to mechanical engineering to study the subject, I want to pick up the most interesting part of electronics. So, that is a choice of my course in school or university.

Q: And before you got to university you mentioned you like to make things, how did you get introduced to those?

Hirochika Inoue: In that time, honestly, that is not so far from after the war, so the economy is very bad, the family could not afford to keep such kind of material around. So, I just received magazines for model aircraft or something and all the time, every time, I'm thinking about the magazine, so most of the design and building was in my brain. And sometimes I made very small things, using convenient things around my home or something. So, I always want to realize there are things, so that is much basis of my life, I think.

Q: And when you decided to do engineering, was engineering a popular kind of field in Japan?

Hirochika Inoue: Yes, yes, yes. In Japan, engineering and technology is very high ranking, I think. For instance, in England, maybe banking is higher, and engineering is not so high in the society. But in Japan, most of the law school is going to the bureaucracy and going a step up, and also other areas that make doctors. And also similarly in Japan, in Japan engineering and making the technologist, engineer is a high position in the society because people who make things by themselves have the value of the society. And particularly in my situation, the economy is going bad compared to right now, going down. So therefore, I think it is a very good way. Anyhow, the strongest motivation is I like it very much, honestly. My mother suggested me to go to law school because law school gives some bureaucrat or something going to the step up in the government and so on. My father suggested me to be a medical doctor because he wanted to be one, but I do not like biology and so on. And also I do not like the law school or something to talk about people, it is not good for me. Therefore, I chose what I really love and I think my decision was correct.

Q: Yes. How did you get into school, what was the process of actually into the University of Tokyo, which is a very highly placed university?

Hirochika Inoue: Yes. I was born in the southern part, the local area far beyond from Tokyo, the south end of the prefecture. So, the gap between the Tokyo standard and the Kawashima standard is enormous. So, honestly, it is very hard to get into the University of Tokyo, that is the narrowest gate for the entrance examination. But fortunately, I succeeded once. So, I tried entrance examination once and that is a successful, so no other things. At that time, not so special preparation for the entrance examination. And the difference of the Tokyo area and the central area and some others, there is a big difference. Therefore, I was very happy. If I were in Tokyo area, everybody works very hard for entrance examination, so I would be forced to work, but in the local area, doing anything, that area is not so good. So therefore, I am very, very happy just thinking how to make, something like that.

Q: When you got into mechanical engineering, what kind of work were people doing, what was the school like?

Hirochika Inoue: In the university, university is actually educational, the real thing is to go to the graduate school and that was the beginning of research and my career. That was 1965, I graduated, so that is the standard, no trouble course. And so when I graduated and entered into the graduate school, I chose one laboratory, one professor. This is a very popular, but I fortunately get into the position. Each laboratory has two seats and I was very happy to get into one of them. When I first got into the graduate school laboratory, my thesis advisor said to us, to my friend: I want one person from mechanical vibration, another is automatic control. And vibration is related to the lateral vibration of the train. So, I think I almost know about the lateral vibration of the train, that is important but I really know about it. So, I do not like to do. So, I suggested to my friend: don't you do that? Then he said yes, so therefore, his topic was decided. Then the professor, or my thesis advisor, said "About the automatic control, we'll consider it a little bit? For a while." And one week later Professor Fuji, his name, said to me, do you like to build mechanical hand to turn a crank? He said so. When I heard about it, I cannot understand what it means, but it is very, very attractive, the mechanical hand and so on. Therefore, I suddenly said, "Yes, I do" without knowing anything. That is the instant I started robotics. But after that, the professor did not say anything. When I talked to professor, my thesis advisor, what shall we do? He said, try anything.

Q: Figure it out yourself.

Hirochika Inoue: Yes, to try anything. And after, then we'll discuss. That is on for five years. Anyhow, in such a way, I decided the topics, but after I graduated, after getting a degree, coming back to the university 15 years later, Professor Fuji said I was wondering at that time, whether the topic is good for student or not. If the topic is not promising, it is dangerous to make one student's life worse, so he is wondering, but he said I was very happy because you succeeded in this, that is the story.

Q: How did you start working on the mechanical hand?

Hirochika Inoue: Yeah, no, I don't know, I don't know robot, honestly, at that time, we have no technical term of robot. So therefore, mechanical engineering, I tried to make, so that is again the start of my love of things to build something. Therefore, I tried to make a hand and to add the sensors to control, mechanical controls and so on. So I tried everyday, just I enjoyed. And I finished my master thesis after two years, then I write papers and that is very successful. In that time, I have no computers and after then, I proceed to the Ph.D. course that is three years more. The master is a two year, three years is doctor, for five years is the least we have in Japan. So

when I proceeded to the doctor course, I am not sure which topics will be there, degree or not. So, I really thought to change my topics.

At that time, one year I tried to change topics to adaptive control for airplanes, particularly for subsonic areas, that is very unstable. Controlling subsonic states to keep the stability of the airplane, that is also very popular topic of that day. So, I studied them very much and analyzed and so on. But, I found the most important point of the airplane dynamics depends on the characteristics of the wing. The wing shape is completely determined by American standards, the standard is given by NASA or something, an American standard. Therefore, if I go to this field, I cannot have complete freedom, therefore I stopped doing it. So, I decided to return back to the mechanical hand and started again. And I tried to find some manipulator, I found some company that tried to make manipulators, not a robot, but a bilateral manipulator, master-slave, to handle the nuclear isotope or something, so that is also called magic hand or something. And so, I found it, then I noted to my professor, I want to use this machine which some company developed, so is it possible to use that? Then professor asked to the company and the company person is a student of this professor and that company person said "Yes, we did, we finished it. So, we do not use it. If you like, you can use it." So we borrowed it for zero money. But after then, I hoped to change and replace and so on.

And then the most hard thing is to get computer. Computer at that time is very, very difficult to get in Japanese areas. So, in that case, University of Tokyo has a project of artificial heart for controlling by computer and so on. Therefore, medical department has one computer that is hooked to control the artificial heart for goat, sheep – no, no goat. That is a size of the, good size. So, I planned to use but unfortunately, at that time, University of Tokyo is a serious problem with radical students opposing to some part in medical school and the student power closed the university for one year. Wow, so therefore, I am seriously afraid. The student took the symbolic tower for several months and every medical student get out. That is like the situated in Berkeley or something, that is a kind of movement, just at that time. So, therefore, that project was done and laboratory was also closed, so I also lost everything. But after that is settled down, that is spring of 1968, when the radical student is getting out and university return back to the normal situation. Then I started again. At that time, professor, my thesis advisor, tried to purchase computers to control my mechanical arm. But unfortunately, the computer which will be arriving to my laboratory is about six months later. That is the truth, too late. Before that I have to finish my thesis. But it is also very lucky that computer company kindly lent me another computer before that, but the contract is just on the six months, so from April 1 to end of September. So, that is the limit of that use on my computer. During that, I changed interface and did the program and completed. Did you see the movie last night?

Q: Mm-hmm.

Hirochika Inoue: That is a movie that I think is the beginning. The point of the research is to use new mechanical control machine for machine tools or something. Computer makes the order, machine faithfully obeys. Therefore, if some robot arm, computer controlled arm to get some limit, then they do it. So therefore, if you grasp, if the order is a little bit smaller, then it crushes it. But we do not do that because we have the sense of a reaction force, compliance and so on. That is necessary for realizing dexterity of the manipulator. That is a key point of the topics, but I don't know when professor suggested to me five years before, conclusion which I get after the four years and so on, that is a point. Therefore, I realized and made the touching thing and whole sensing, there whole point when put something on floor, after landing with this, never like this. So, we wanted to do that, this object has no sensors. If this hand touches, the hand has touch sensors, that's okay. But this usual object has no sensors, though sensor things must know the touch or not. That is through this reaction force. That's a good point. Using this, we can carefully put the peg in the hole and time the crank rotation. That is the point I think maybe this is a most important point of the study for robotics. I think this trial opened this, the idea worked for the assembly and so on.

Q: And what kind of sensors were you using?

Hirochika Inoue: Yes. Yesterday if we have a good microphone and I would like to say, but sensors. Touch sensors I made, about sixteen touch sensors on hand. So many hand by only the touch sensors we can take some part was on. But the sensors to detect force, there are many ways. One is to get some special sensors, which right now they do. But at that time, we had no touch sensors, therefore, anyway, I will try. You know feedback system, you know servo system, that right. Then the position servo system, the computer gives a position difference, then servo system feedbacks to keep that feedback signals to zero. So, that is a system of feedback. Therefore, usually the numerical control gives a command by the difference. Then it's a sound system very precisely follows. But the difference of the feedback signal, the error signal includes some reaction force. So, taking that reaction force, error signals and making the filters I detect some disturbances. So, this is something like this disturbance, so it has an error, so this error signal includes the result of the disturbance. Therefore, using this seems right. So, that's why not special things, I think right now, PR2 of Willow Garage is using that system to give the very stable and not so sensitive enough, but very stable, cheap way, conventional way to do.

Q: When you finished after five years, what did you decide to do?

Hirochika Inoue: It is also, so interesting story. When I have to find some job to that is a serious problem. Before completing my thesis, I have no time to think about what I should really do from that time. After I completed the thesis and I started to search job and so on and my professor suggested to visit some university as an assistant, so I tried to go. But that institute and the university is a servo systems. But when I talked about the professors, they're thinking is very

hard, so I don't like this way. And therefore, I do not like the goal. And after I completed my experiment, very Japanese big company Hitachi is also starting robot. And they know about my work, so after completed, they asked me to teach the result of how you design. So therefore, professor suggested to teach them. I don't know the background, but anyhow, I went for several weeks to go to the research laboratory to explain my program and so on, how did I do that.

Therefore, that company want me to come, but I do not want to go. I need freedom. At that time, occasionally, I meet professor Shirai, next interview person, he is one year elder, after he received doctors then he get the electro-technical laboratory and I met him. What are you doing now in electro-technical laboratory? I'm doing some vision systems. Is it interesting place? Oh, yes it is. So, then shall that laboratory hire me or not? He asked me because I have to find, okay, I try to talk to his boss. Then next day he came, telephone call, yes, our boss will hire you, come soon. Great. That time, more than 40 years, so that is free stage, the situation was Japanese society is the not same complications and the economic condition is not so good, but they are very, very altruistic, very, very forward looking and therefore, very, very flexible. In such a way, I went, I joined to laboratory.

Q: At the time you were doing this work, were there other people who were doing similar things?

Hirochika Inoue: Yeah, about robotics?

Q: Mm-hmm.

Hirochika Inoue: In university, no. Just only myself. And professor suggested before me, my thesis advisor suggested to do, but other people do not want to do that. So, that is just only myself and also at Waseda University some group is trying to do robotic matters at some laboratory. And that year research competition start from 1970, when I joined to the electro-technical laboratory, each year at that time, had a project to make intelligent robot, in other words, hand eye systems. So the vision system and manipulator system making together for simple visionary task by error control. And at that time there is competition, I think at that time, that kind of group in the world, in United States there were three: Stanford, MIT and SRI, they are doing this work in a big group. And in England, Edinburgh University. And in Japan, too. One is electro-technical laboratory, another is Hitachi so that is the six big groups are challenging to the computer driven robot. So, that is the early beginning of my career. And within that, joining that, my background is mechanical engineering and in that electro-technical laboratory they have a background of electronic engineering and the computer science and also the mathematics and so on. They get that together in building the systems. And they put big money in that time going when you think about. So in such a way, we very young person, age

about 30 or so, and more than ten people working every day and night at the laboratory to build something.

Usually, when somebody joins to the institute or laboratory, first three months is education, usually. But in my case, they have a plan to open the result of hand eye system in September, so April, from about five months, so therefore they need my effort soon. So, just only one month education, I go into the lab, I was very happy. So after then, I joined and then completed the hand-eye system. Within three months, I did three important papers at that time. One is the operating system, one is hand-eye system. Another is the visual feedback motions with Shirai-san. That is the three big ones within the first year. So, I think the first success experience is very, very important for careers and so on. If I fail the first attempt then I don't know things. So, when I educate students, I try to give the opportunity to feel the success for the student and so on. And in such a way, we succeeded very much and it continued and the success of the result is open to the newspaper and at that time, not so popular in TV and so on. The result is spread within the world and so, and MIT, Stanford, SRI, Edinburgh, Hitachi, is collaborating, collaborating and competing together. So, that is a very good area for me. Most of the people who is engaged in the robotics research, particularly for hand-eye system, all I know – most of the researchers I know just owned these papers. At that time, information is not enough. Very small channels. Therefore, we have enough time to try. Right now, too much Internet and too much information. So, researchers seems to find time to do their research.

Q: How did you get the papers from other people?

Hirochika Inoue: Reading some journals.

Q: Did ETL have a library?

Hirochika Inoue: Yes, yes. So, that is very good. If I was in university laboratory, the budget is limited, but ETL is a Japanese Electrotechnical laboratory, the most advanced laboratory and that is also the government policy to promote electronics. There are many money, so therefore, many libraries that we have.

Q: And so, it was funded by METI, right?

Hirochika Inoue: Yes.

Q: Was there a vision for using these kinds of hand-eye systems for industrial robots – or why did they decide to fund that kind of project?

Hirochika Inoue: Good point. At that time, actually, the industrial robot is emerging. It's just spraying or spot welding, some on computers, particularly most of them are spraying with not much control. So, they say the result will go into the industry, but honestly, they want to develop the leading-edge of that technology, who are looking for the ten years or so. Of course, the METI officers and the laboratory managers are experts. This is important for the industrial robot and also for future Japanese industry. That is going to get money they say, but they make us very free to try the first thing, the most good thing in the world. So, it is a very good edge.

Q: How many people were on the team?

Hirochika Inoue: I think less than 20; about 10 for manipulator control, manipulator and about 5-6 or 7 for vision. That is different laboratories. Shirai-san's laboratory, vision laboratory, and automatic control laboratory. So, that is about 10 or 5 or something like that.

Q: Who were the other people that you worked closely or worked with?

Hirochika Inoue: Oh, most of the people is going to the universities and professors. So, I can't count everybody. So, to me, that is, in some sense, that is praise of my good usage. So, everybody shares that time.

Q: And so, after this first big success, what kind of projects did you...

Hirochika Inoue: We can continue that.

Q: ...at ETL?

Hirochika Inoue: Yes, ETL; we can continue after that – enough money. First open experiment is successful, therefore the funding, it produces very much. We can keep enough money since then, but I do not stay for a long time at ETL. I visit to MIT about one year and at that time, staying at A.I. Laboratory and I found some intelligence, artificial intelligence. So, I got a marriage of the computer and intelligent robot. So, that is the way of finding – intelligent robot system actually. So, I did MIT. Yesterday, I skipped the movie, but 1000.00 inch creates very precise assembly. It was done in 1973 after then I returned back and then University of Tokyo suggested to me to come back to university. It takes a long time to negotiate, not myself and university, but the problem is ETL and the university because if I moved to university, that is also some problem. So, in order to keep the peace within these today, it takes a long time, more than two years or so. I graduated in <inaudible> and moved to university.

Q: So, ETL sent you to MIT.

Hirochika Inoue: Yes, yes I returned back, and stayed three years, and moved to university. And, during I am staying in ETL, I have enough funding, very happy days. The jobs in the lab for which I have to do is just do it, research. So the first seven, first eight years after getting degree, that is 100% design, that was very good. Then when I returned back to university, very busy with student and with some meeting and so on.

Q: So, when you went to MIT, what was going on there? Who was there?

Hirochika Inoue: MIT?

Q: Mm-hmm.

Hirochika Inoue: Professor Marvin Minsky and also just at the time, the laboratory head changed to Patrick Winston. And at that time – for instance, the people who is now coming is John Hollerbach was a student and Thomas Lozano-Perez was also a student when I visited. So, a long time ago.

Q: And what kind of work were they doing?

Hirochika Inoue: Lozano-Perez is trying at that time to make robot language system for his PhD thesis. So, the higher software. And John Hollerbach is the control matters.

Q: And Minsky and –

Hirochika Inoue: Minsky is engineering chief, right, philosophically, but he likes to build a machine very much. So, he understands everything.

Q: And did they have any robots then at MIT?

Hirochika Inoue: I was supported by Japanese government. So, I have no obligation. Instead, they have no request to me. So, it is sometimes good; it is sometimes bad. So otherwise, if I found something by myself, they say anything. So, honestly, at that time, for the first several months, it's very, very hard to communicate. My English at that time is very, very hard to listen and so on. I was thinking about getting a computer system, difference between computer is very,

very enormous at that time. So, U.S., a big computer; thinking about Japan, small computer. We can't compete against each other and so on. But, anyhow, I would teach how to think about, but as long as I stayed there, I had to do something in the laboratory and to give some result. That is 1000th of an inch precise assembly tasks. I think they are applying the mini robot proposal to DARPA at that time, but nobody is doing the assemblies. So, I said that is very good at that time.

Q: Did they have an arm?

Hirochika Inoue: Yes, they have, not an arm. Some devices is already did somebody and interface together, but nobody is thinking about how to use it. So, for me, it is easy to do it because I have experience in university to how to do assembly. So, that kind of things will be defined and programmed precisely. So, to me it is easy, but the result is very good I think.

Q: You mentioned in MIT you learned about A.I., artificial intelligence. Are there other things that you noticed or learned while you are MIT that were different?

Hirochika Inoue: Yes. It is interesting interview, I think. I stayed, I went to A.I. laboratory to run and study intelligence, A.I. – what is A.I. – and to look for topics on A.I. But, after staying there, I know I couldn't do A.I. The reason is in my English capability, I cannot read about the A.I. because the result must be discussed and talked to each other in English with the top ranking people in that case. If I think something, I cannot express, maybe less than 10% of my thinking. So therefore, if I go into that, maybe I cannot win. But, if I do the experiment and show the result by reality, then I can do everything. Therefore, the thing which I should do in my life is not to do the A.I., but do the reality or the control and the vision connection and so on. And, when I turn back, I think I like intelligence. So, if somebody, younger generation, younger people has an interesting about intelligence then I will support that in such a way. After I moved to the university actually I had a very good student who want to do the intelligence matters. I cannot teach them intelligence, but I can answer what they are doing correct or not, meaningful or not, but suggest them – that is a way for which I was taught in my university, my teachers at the university – “Try it, then after then we'll talk.” So, try. It is a way to give originality, to find their own ideas. That is important in the university environment.

Q: So, when you go to the university, what was the environment like? How did you start your lab?

Hirochika Inoue: From heaven to hell. Well, yes, particularly. Maybe the budget is 100 times different, university. So, almost zero budget, very small budget. At ETL, we enjoyed the budget. But, it is very good for me, student is interested to do new things. So, very smart

student placed their eyes on my work. So, they come into the laboratories. The thing which I do is to encourage them and to make the room and atmosphere and something, some small things to challenge them. So, the start is very economically, the budget is very small, but with a small budget, our power and intelligence of student challenged me. And gradually, we get the fund and accumulated everything. And so, at that time, when I moved to university in age 36, at that time, I think my retirement age was age 60, strictly determined in Japan. So there, I have 24 years from that time. So, I have decided to do the intelligent robot system in my laboratory, the top ranking laboratory. I have nothing. So, I can admit that. Therefore, I have a very long time planned.

The important topics is manipulation, mobility, vision and perception, and intelligence and also integration, system integration. So, we have five topics. Then in my laboratory, I decided to do everything in my laboratory. If five student comes, five student will do one thing. So, they are doing different things. So, they can cooperate, competing and cooperating. And, also we give the topics for the student. I have to give the topics to the student. If he goes into the doctor's course, then five years. So, the topics must be good enough if that student will complete in five years time. So, very good topics will be given and I do not teach anything. So, I just observing and talking and let them do something and prepare some things. But, today, I have no materials right now. My final lecture when I retired in university, our university give a memory and a final lecture. That is really the final lecture. At that time, I have one seat, the history of my laboratory. So, every year, what kind of things is done by you and so on? So, the accumulation of the vision development, parallel manipulator developed by ourselves and the vision system, vision eyesight is also designed, intelligence is also done and the system is also done by mobile robot and also some human controlled scooter systems like an automobile.

And, I trust about the end of the last century, 1996 or so, I started; I realized to start building humanoid. That is a very good source to integrate everything – the vision system and manipulation, mobility, leg, and intelligence, and communication interface. And also, the size and the volume, the weight is limited. We think that limit, everything must be entered. So, therefore, I think that is a very important shape is something like the humans because the humanoid is expected to use the object which is used for human's everyday life. So, the size is all the same and also the size of the robot must be all the same because all the environment is designed for humans. Therefore, to go through the narrow space and so on in such a way that a strong imitation is good to advance the technologies. That is also very successful because I had a very good student. About 30 doctor student, about 30 doctor student means 30 good topics as a result. So, everything must be integrated into. And Professor Inaba right now attending here, he's one of the students. He's a software vision system person. He continues keeping the system management and so on. So, laboratory, we go to JSK. Jouhou means in Japanese – you know Jouhou?

Q: No.

Hirochika Inoue: No. Jouhou in Japanese, information. System is a system. “K” is Kougaku, engineering. Information System Engineering Laboratory; that is a very good topic for robotics, particularly humanoid. It includes everything. So, I think in my history of my laboratory everything is – and also, an important thing is all the key element is completely white. That means everything is designed – done, programmed, everything – inside the laboratory. So, every detail somebody knows. We have never bought the black box things. Of course, computer is but the interpreter is also developed by ourselves in such a way. So, that is the treasure of my JSK laboratory. That is an infrastructure of doing the intelligent robot system. So, if some new devices is coming out, we can easily build in our systems. We graduate, in such a way, the robot system, graduate year-by-year, student-by-student. And so, we have many exiting experiment.

Q: Some people talk about this kind of in-house development, or building robots that are very specific to the laboratory is making sharing difficult between labs, sharing of information. What do you think about that?

Hirochika Inoue: Yes, maybe. That is very, very difficult to do in one laboratory right now. But, we started very early. Every time, we walk or run at the front. Therefore, we have nothing we want. We have to make by ourselves. Therefore, we can do it. But as you pointed out, right now, the robot technology is maturing. And so, you can get the systems easily. For instance, some robot systems and software systems also. So in such a way, the common software must be used and using that infrastructure, including hardware systems and software systems, to put in invention and so on. Putting it into that infrastructure, he must create new system and so on. So, in order to do the quick and good system, that is the most important thing for everybody in the world. I think the Willow Garage approach is also succeeding. But also, in such a case, as you pointed out, in robot case, in computer system – in computer case, computer is sold by a company, that is practical. So, they can use software and every day we can change it. But in robot case, robot hardware must be purchased, but the robot which the company sells is not good enough. But, I think it is very important to make this really universal. Really valuable, new, flexible hardware system as a research platform is needed.

Therefore, simultaneously, in university, we took by ourselves. But in METI, MITI changed its name METI, in METI projects, I had been the project leader of Japanese human robot systems since 19 – about ten years ago. At that time, the point is to build a platform, a research platform for the humanoid and develop as a national project and to put some cooperating systems and basic software systems and using that system will be sent to the laboratory. So, therefore, the robot system, even humanoid, is about ten years ago or less than 10 years ago without building humanoid. Anybody can do humanoid research in experiment if they have money. Even we have money, we cannot take <inaudible>. So, the project was succeeded. We had the HRP2 and right now HRP4 succeeding, either singing or dancing together. So, that is also a great project. Therefore, in that time, I am doing – university research in the laboratory. This national project is different, completely different Inaba-sensei, and my student mainly do

JSK humanoid system. That is much more advanced, complete voice system. This is not transferrable to other systems because nobody can maintain the systems, just only JSK maintains it. But, the humanoid system, HRP system, can be sold. I asked to Kawada Industry to sell it. So, in such a way, humanoid and that kind of system comes to market. So, if somebody has purchased it and they have some key technology they play something in such a way they are doing.

Q: What are some of the other robotic systems you developed in your lab before developing the humanoid?

Hirochika Inoue: Humanoid?

Q: You said kind of the manipulators.

Hirochika Inoue: Yes, for instance parallel manipulator. Right now, the Stewart platform parallel manipulator. Usually, this is a motor arranged in serial way. So, this motor is a heavy. So, this motor must – the parallel manipulator is like this kind of a thing. Anyhow, the arm, several arm is incorporated, moving like this. So, in such a way, that idea I got in MIT in 1973. Marvin Minsky wrote some essay about parallel manipulator. So in that case, yes. I tried to make it sometimes. So, after I returned, moved to the university, I started and my student made it and that is about more than 20 years. So, when we first did then somebody will follow. Then it will move like that. And also, the vision systems; vision chip, particularly vision research. Researchers of vision system, like Shirai-sensei and so on, is vision treated as their research. There are precision and how complex objects can be presented and formed. But in robot case, speed is important, to put the vision system in the loop. Therefore, the other time vision system is needed. Therefore, I build the real time vision system two, three, kind of vision systems I myself tried to design. I have to ask the company, ask to build it. In developing, I did not use money. I didn't – in my life, in my university budget, I don't need so much budget.

Q: So, you mentioned that students are just interested. So, they contribute time. How are students in Japan funded? Are they usually <inaudible> the university?

Hirochika Inoue: No, no, no. Basically, Japanese student, even graduate student, pay themselves, but things are changing a little bit because they are studying university. So, what we need is to prepare some salaries. But, things are changing very much recently. So therefore, they come into, but of course, we have to prepare much more things for them for their support. That is the source of the interest and the sort of the intelligence with them and so on. The things which I prepare is that kind of materials and the environment and so on. And the student and myself discuss this is interesting and they shall redesign it all good – then try it. Then in that

case, we try the prototype and show some company. Then the company, they build it. I think first prototype must be done within university without company. If the result is good, then company pay money and they make themselves and the return back free. In such a way, of course, we get the fund and something. We gradually made it. So, the manipulator system and the locomotion systems and also the vision systems and the computer programming system, everything developed.

So, in some sense, I think I actually do everything. But I want to introduce myself, I do everything then most people consider doing everything is almost impossible. Therefore, maybe each of the result will be low for doing everything. But in my mind, each component, subsystem must be top ranking and everything must be together. So, that is my confidence and the source of my confidence is not myself, because the students are very eager, interested, talented students gathered together. So I think it was very, very happy, very lucky and timely and in that time, University of Tokyo is a very good place because that is a source of very super-powered students gathered together. And that is a just the way to show some interesting topics for the smart student, they can evaluate smart things that are good or not for their own sake.

Q: Which companies did you work with on some of these robots?

Hirochika Inoue: Robot, mostly, I designed and asked, recently the car industry to build a humanoid.

Q: Earlier, who else did you get, I was just curious what interested in building them for?

Hirochika Inoue: Not specially, sometimes I will find some friend, I think it is interesting to do just for doing, so Sumitomo or Mitsubishi Electric and so on, not dedicated to one place. But I think if I show some prototype, then the company which have paid attention to this, that we will make some product or something. Not again money profit, but occasional and so on.

Q: And maybe knowledge.

Hirochika Inoue: Yeah. That, basically in my way of life in management, in university, that is exceptionally university, not cooperating companies, not cooperating government or researches, government project, why? That is to keep any direction for student. If we have some cooperation with outside, then we have to promise something. The promise must be done by student inside. So there, as long as possible, as much as possible, I want to be free.

Q: Does University of Tokyo have some general funds that they give?

Hirochika Inoue: Yes, yes. No, no, no, I get a fund from JSP like NASA or something, a prize. So, not so much. Not much money is enough, not necessary. In my case, generally speaking, money the much more the better, I don't think so. In research case, money is a need, 80% of needed would be very good. 20% less, that will be covered by our wisdom. That is a source of invention.

Q: Are there any other projects that you want to mention?

Hirochika Inoue: Yes, in my research theory, mainly university environment, the university, the main purpose is education. Education through research and top purpose is to educate the student. And educating student, the student will change society. But I have to do something, so in that area I also did some coordinated research for Japanese universities after I was middle-aged, 50 or so, then I think it is the road for duty, for us. So, the project leader of the entire university decides the ministry and they owned about a 100 laboratories inside Japan. And that is one way, another way is the national project, like the humanoid. Later on, I also contributed to some societies, that is in 9/2005, we had the Expo in Nagoya. At that time, METI is also the sponsor of the Expo, therefore METI must prepare some demonstration in that time. So, therefore, I also did a project leader for the expo event. That is a very big grant and about more than 50,000,000 in dollars and also in borrowed labs, about 50 university laboratories I asked to build a robot and together assemble into the society. That, thinking about the robotized society in 20 years or something, so we shared some manipulations of robots, service robot, communication robot, and so on. So, that is also some work which I did in such a way. So, I think when doing research, I like robot very much, the thing which I engaged in this idea, robot, just only robot.

I am very happy from the beginning of the day in 1965 until today, I just only build robot. And gradually, it is <inaudible> age. I think that is very, very lucky for me. I was born in very good year actually. If I was born ten year later, that is bad, ten years earlier, that is also very bad. So, I think very, very bad, so I feel of it, therefore I have to return back everything in academia, in education, I am confident to educate student, many, many very good student. In university research, in coordinated university research, with the big university and tiny university project and for industry, I did the national project for humanoid and for society, I also served to some Expo and so on.

Q: I visited the Expo.

Hirochika Inoue: Oh, you did?

Q: Yes, yes.

Hirochika Inoue: So, maybe you enjoyed something, yeah.

Q: Yeah, did the do you do the robot house part?

Hirochika Inoue: Yes, yes, yes.

Q: Okay.

Hirochika Inoue: Robot house and that is some robot dinosaur and so on.

Q: Yes.

Hirochika Inoue: That is specially designed. The dinosaur robot too, bipedal locomotion. That is a humanoid technology transferred into, and at that time Toyota is also doing about it. I also suggested them to do, so mostly that Expo is called Expo of robot. I think that is very good. And another thing which I mention is, you know mechatronics, the word. I was strongly committed to invent that mechatronics. In IEEE Spectrum, some materials you can find about how mechatronics is born, but that is just moving from electro-technical laboratory to university. In the late 1970, MITI is thinking about new industry, so that is a mechanical engineering university and electronics industry to marry together so the electronic control machine, that kind of family of the products will be the very promising. MITI consider so. So, therefore, they make the new word, synthesizing mechanics plus electronics, so mechatronics.

Therefore, at that time, MITI asked me to study or research, to search about, to define that major and where to go. That is very important. That is the start of the concept of academic and technological concept of mechatronics. And that at one point I am strongly involved in late nineties and also twenty years ago, I also formed university department and this year is twenty years. When I moved up in '97, in '78, in that time when I turn back, mechanical engineering is not so going up. Electrical engineering is good but mechanical is stale. But I did robotics and robotics is a marriage of electronic engineering so I think education for mechanical engineers is needed to put into electronics and computer science. Therefore, the curriculum must be completely changed. Roughly speaking, one-third of the old mechanical engineering will be depressed and that one-third, electronics and the computer science, it must be coming into.

So, that is a real difference from the classical, traditional mechanical engineering. But we need this, without this education, JSK cannot be survive. And also without this education, our future of Japanese industry, therefore with our colleagues, we decided to reform the curriculum and make the curriculum course towards mechanics and so on. At that time, we

easily can define the word in Japanese. mechanic Kikai Jouhou system, Kikai is mechanical engineering, and Jouhou is information science. So, in Japanese we can say mechanical and information engineering. But the word is no good. But, so I find the good word, fortunately at that time, there was Ruzen Bajcsy, she is my friend and she is staying in our university for a while, staying in my house for a week and so on, we are discussing, we are thinking about this kind of a new department, a curriculum like this and intending to educate the science in such a way, but I cannot find the right name. So Ruzena how do you think about that? She thought for a long time and she said how about mechano-informatics. I got it, then I made it department of mechano-informatics. I think that is a good term. So, the mechano-informatics get a familiarity for the student, very good student coming and going. So, I am thinking back for my life I was very, very happy in doing that, my real experiment is up to electrotechnical laboratory, so up to 36 I think. After then, it was through the education of the student. In the first thing, through the university, entire university and industry, in such a way, many things can be done. But I am not so busy man, because I am not doing so much. I am doing one thing. So, doing the research just on the robot. Doing the education just on the mechano-informatics, doing the national projects just on the robotics. I am not involved in other robotics simultaneously. But, I think my duty has almost be done in those ways. So, it is a problem what shall I do from now.

Q: I'm sure you'll think of something.

Hirochika Inoue: No, no, no.

Q: Too much freedom now.

Hirochika Inoue: Right now, I retired university – 2004, that is historically age you retire. After then, I was appointed the inspector general of JSPS, like the NASA and about six years, I was there. And after then, so about two years, I'm advisor to the AIST and I'm enjoying. Advisor does not ever drive something. Advisor is a very good place to be, advise for other people. So I'm enjoying it a bit much. So, I think in this case, in this symposium, Oussama asked me to chair the Beyond the Horizon session. I feel that is a very good chance from many standpoint, so Obama's OSTP and the NSF fund in such a way, Europe and Japan and the United States and also that kind of thing to think about, to make the good balance is very good. I think not a step down, step out, but to step aside one step makes thinking very free. So, we can see everything. If I was inside or have to compete, so inside here I am enjoying it very much. Particularly, ISRR is one of my main comforters. Since the first one I have been in this year, I was very, very happy to be involved in this.

Q: What were some other important conferences and venues for you?

Hirochika Inoue: This is the best to me. And also in Japan, Robotic Society of Japan and also IEEE, ICRA I think right now, honestly, most of the robotics researchers in Japan, that is of course they are robotics society of members, but mainly they are involved typically in robotics and automation. So, I think recently. Before IEEE I think the Institute of electronic engineering and electronics or something like that. But now, The IEEE, no explanation, so that is very good. Not USA, but global. So, I think IEEE it is a very good to think about it. Very good, so sometimes this is some diplomatic issue. Yeah, yes.

Q: You mentioned that you worked a lot with your students and in the beginning with Shirai-sensei. Who are some of the other people that you worked with closely or had good discussions with, good relationships with over your career?

Hirochika Inoue: I count many.

Q: Too many.

Hirochika Inoue: Too many. Everybody here. So, I count that mostly is Takasa Sensei or Hanafusa Sensei, everybody I think around here. They are Nakamura Sensei and also Professor Nakamura is a graduate I think, at Kyoto University and he is involved with Hanafusa Sensei back in the organized our second ISR, Hanafusa Sensei and I, myself, organized and at that time, Nakamura Sensei is an assistant to and after then, he moved to the Santa Barbara University and he's working. I look over him from Japan. He is doing very good. So, we're catching up to university, our university. So he is now mechano-informatics. So I'm looking over him.

Q: In Japan, you mentioned when you just started, robots weren't even something that people were interested in or people were kind of afraid of doing that kind of work. But now, Japan is very well known for robots. So, could you give a little bit of an explanation of what helped changed that?

Hirochika Inoue: Japanese people likes robot very much. I think that is the nature of Asia. Not only Japan, that of Vietnam or Thailand or Singapore and Asian country peoples like, thinks robot as a friend, not opponent.

Q: But do you think that the government has had because they have funding pushes for certain things?

Hirochika Inoue: Good point, good point, good point. Honestly, in Japan, particularly for the MITI, METI considers robotics or mechatronics as very important and continues funding and

still continuing. But the increase is not now. Instead, Obama declared two months ago a new policy and <inaudible> is appointed as that. So, in such a way, US clearly declared that the robotics is the new industry of this century and to increase the job of society for them. So, that is right and the content and the philosophy of that is almost same to Japan. So, maybe from our standpoint, US is doing almost same thing, I mean, in much more budget. Now, and also in EU, European Commission is thinking about Framework 7 and the Framework 8 and so on, they are in current debate.

Some sort of material is agriculture industry, if we consider other industry, food industry and also not the engine or not hard things, flexible things. The robot is a little bit changing. And the service robot, with the interface with the human, human needs more safety and the flexibility is needed. So, here is a traditional industry and also the new service industry including some small industry for family industry and so on, that collaboration of robotic device plus a human. The hard work is done by human, some of the tedious work is done in such a way, we have to create new job opportunity. Maybe Obama administration thinks about it.

And also, the topics will be going into service industry to support the population decreasing in Japan. And Japan is a population decreasing and elderly is increasing, there completely we have to keep the efficiency of the work. Otherwise, we have to care by ourselves. To me, maybe safe. In my life, not so long time. But within 50 years, people is decreasing how much, so I think the service robot, but I think to do it, the price must be going down. And therefore, yesterday did you see the robot bridge? No? The Willow Garage person, see in thinking about internet to robotics and so on, the population who is committed to that technology, robot is small, application of robot is a little bit larger and then application is much more robotic devices and internet and much more. So, the robotic and the robotic device would be climb up this, so one day, it matches to the internet, then every robotic device will be controlled by a robot in my brain. Human will be spread in morphology and then moving to house, then the inside of the room, the humanoid in such a way that software architecture and the application architecture is the same. So, the service robot industry, that is also same. The important now maybe gradually support of service robot will be coming into.

So, two things. One is to move him or herself, that is an advanced mobility, so including the power suits mobility, that kind. That is moving himself, that is also important for everybody, another is moving something, this thing or heavy thing inside, that is also robot. There's a service robot and so on, in such a case.

Q: What are some of the big challenges that robotics is going to be dealing with in the next ten, twenty years, do you think?

Hirochika Inoue: I think that is a compliance, the softness, the material must be soft, the component must be soft, like I pointed out at the assembly. That is just only this work. That work must be interaction between human and robot or machine must be compliant. So, when we move something, in order to keep object like this, we make this part, but in that context we must make this moving efficiency, in order to do that, the contact of this must be carefully controlled and this soft must be done. So, that when I'm thinking about the manipulation, in that case, this must be soft, not hard. If this part becomes soft, the feelings become changing. Sometimes no physics is needed, so...

Q: So, we have one last question unless you have something to add that we missed.

Hirochika Inoue: In this interview?

Q: Mm-hmm.

Hirochika Inoue: No.

Q: No.

Hirochika Inoue: I enjoyed.

Q: One last question.

Hirochika Inoue: Yeah.

Q: We want to have a small part of the site where it's just kind of motivating young students. If you had some advice to give to young people, who are interested in robotics?

Hirochika Inoue: Keep the dream.

Q: Keep dreaming.

Hirochika Inoue: Keep the dream to create promising future.

Q: Thank you.

Hirochika Inoue: Okay.

Q: Thank you very much for your time.