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Maja Mataric

An interview conducted by
[Interviewer Name]
with
[Names and identities of any other people who were present and active participants]

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Peter Asaro: So we're just going to start with some questions about you, where you were born, where you grew up, where you went to school.

Maja Mataric: Sure. That's the question? Okay. <laughs> All right, so I was born in Belgrade, Yugoslavia many years ago. I like to think of it as being born a long, long time ago in a land far, far away, so it's an ever-shrinking country. And I did basically my first 16 years of life in formal education there. And I was interested in computers back then, but it was a very different world. And then I moved to the states and everything changed.

Peter Asaro: Where did you do your undergraduate?

Maja Mataric: So my undergraduate was at the University of Kansas in computer science. I also minored in neuroscience and in commercial design, keeping it broad. <laughs>

Peter Asaro: Have you used the commercial design? <laughs>

Maja Mataric: No, I never have. Actually, when I was an undergraduate I realized that my interests were really somewhere in the area of what is now called cognitive science and neuroscience but back then was still sort of under psychology and just emerging as a new field and at the same time in computation. And so I figured that the intersection between those two was basically AI, artificial intelligence, and so I studied AI, but what I really was interested in turned out to be robotics. And only later I realized that AI and robotics are not necessarily subsets of each other, and they have an intersection but they're not the same.

Peter Asaro: How did you first become interested in robotics?

Maja Mataric: I became initially interested in robotics as an undergrad when I was looking for directed reading courses in addition to my regular coursework because one can take computer science and then one wants to do additional sort of more in-depth study, and so I discovered a little bit about robotics. And the first thing I discovered about robotics actually was industrial robotics, and that turns out to be completely different from anything that I ended up studying or doing, but it was my first inkling of what robots could possibly do, and so that's what I started to look.

Peter Asaro: What kind of industrial robots did you come across?

Maja Mataric: So basically my first contact with robotics was the directed reading class in which I looked for robotics textbooks and there weren't very many because the field was still relatively new. And I found a textbook on standard industrial robotics, and so I read about arm manipulator robots that assemble cars pretty much, and this was before the era of DNA sequencing, which is the next exciting thing that small manipulator robots did. So I read up on that, and I wasn't terribly enthused but it was a start.

Peter Asaro: And then you went to MIT to study artificial intelligence or computer science or both?

Maja Mataric: Right, so the big major thing for me as an undergrad was getting accepted into MIT for graduate school, and so I went over there and back then the first-year students had the luxury in computer science, course six, of looking around at different projects and selecting what would work for them, and we were funded for the first year. So I looked around and, really, even though I had some interest in robotics, I had interest in AI, I had interest in many things. I remember my application essay talked about neural networks and expert systems, so that really goes way back. But when I talked to the faculty at the MIT AI lab I realized that I was really very interested in the work that Rodney Brooks was going, and he was doing robotics, so that was what determined it.

Peter Asaro: And so you became a student at that time?

Maja Mataric: So I became a student in Rodney Brooks' lab, and he was working on a completely new kind of robotics and certainly was a new and exciting area back then, which was reactive and behavior-based systems, and that's what ended up shaping my Ph.D. direction and then my work subsequently.

Peter Asaro: So what was the first project that you worked on at that lab?

Maja Mataric: So my first project in robotics, my first real work in robotics was in graduate school. Everything before that was reading, and so the very first work that I actually did was my masters thesis work and that was on navigation. Ironically, when I started out my masters thesis work I was going to work on underwater robots, and there was a whole lot of reality involved with working with robots underwater, and I realized that my interests had nothing to do with that. My interests all had to do with recognizing places, forming a cognitive map, being inspired by some neuroscience literature, and so then I threw away all of the underwater stuff and ended up working on a navigation masters thesis that was on a robot named Toto that got quite a bit of fame later, and I was fortunate to be known as the person who did Toto.

<laughter>

Peter Asaro: And what did Toto do?

Maja Mataric: Well, Toto was a fun robot because I was inspired by finding my way around Boston, which as many people know is laid down on cow paths, so that was a challenge, and also looking at neuroscience evidence on how people or at least rats might navigate. So I was looking at a very different way of doing navigation that was traditionally done in robot maps, which were Cartesian representations. So I ended up doing a topological representation, sort of a place cell, place topographic, topological representation of space, and that's what my robot Toto did. And Toto could recognize places and go back to places and build this very relational map as opposed to an absolute Cartesian map. And it was interesting because many people later said, "Oh, so you must've done it that way because that's how maybe women think about space or uh..." <laughs> I just thought that was funny because I really did it because it was different from the way it was classically done and because there was neuroscience evidence for that being biologically sound.

Peter Asaro: Were there other women in the lab where you were working?

Maja Mataric: There were a few women at our lab, not as many as there are today, and certainly the trend towards getting more women into computer science and into robotics has been effective, but there were some. And I would definitely say that while we were a minority we were not a silent minority. I mean I loved being at the AI lab at MIT, and I think that was manifested for all of us because we tended – the average time to get a Ph.D. in my day was seven years, and that was because I think largely people liked to stick around.

Peter Asaro: And were the other women also working in robotics or in other areas of AI?

Maja Mataric: As it turns out, actually, when I was getting my Ph.D. there was a disproportionately large number of the women at the AI lab in robotics, so I think there was a lot of interest, and we see this over time now that there's a lot of interest in robotics on the part of women researchers. So robotics has a disproportionate number of women compared to some other areas of computer science, and that's been true from the start and that certainly was true when I was a grad student.

Peter Asaro: Did you continue working on Toto for your Ph.D. or did you start a different project?

Maja Mataric: No, I'd rudely dropped Toto when I finished my masters degree, and some people said, "Oh, you should've stuck with that," which I thought, that hurt. What are you saying? Did you not like what I did subsequently? But really the way that things worked out was that, one, we usually do a masters project and then move onto something entirely different for a Ph.D. And, in fact, subsequently people at MIT realized that this takes too long. People are taking too long. So now I think it's much more streamlined. But historically back when I was in the program everyone did a masters in one thing and a Ph.D. in a rather different thing. And for me the Ph.D. ended up being a very different thing, and that was looking at the ________ of robotics, teams of robots. I was very fortunate because my advisor, Rodney Brooks, was able to actually acquire enough support to purchase 20 robots, so I had literally a herd, and we called it the Nerd Herd, and it was the herd of robots that I had to develop algorithms to literally get them to herd, to flock, to follow, to disperse, to aggregate. It was a lot of fun and it was a lot of work.

Peter Asaro: Did you get a sheepdog?

Maja Mataric: I was supposed to be the sheepdog and the shepherdess and everything rolled into one, and I'll always remember my late nights at the lab with big boots because it's Boston, right, so it's cold, and I'd be stomping around in some frustration around my robots. I never stepped on any.

Peter Asaro: That's good, that's good. So apart from Rodney did you study with anybody else at MIT that you found very influential in your work?

Maja Mataric: Well, so there were a lot of great people at MIT when I was a grad student. There are a lot of great people there now as well. I would say that the most important part of the culture, though, was the peer group, so it was the graduate students that were all really working not together. Everybody had their own project, and group projects were discouraged because you had to make your own mark on the field, but we talked constantly. We had these playrooms, large open areas and the social dynamics that made that our intellectual home were incredibly important. I think that was the ultimate shaping experience of the Ph.D. career. Of course the advisor is very important, and my advisor was very enabling in terms of providing the resources and the guidance, but in the end it was the intellectual culture around the rest of the students, and I think you'll hear everyone saying that, and that's something that I think all of us who became academics have tried to replicate in our own labs.

Peter Asaro: Any names that you can recall?

Maja Mataric: Of peer students?

Peter Asaro: Yeah.

Maja Mataric: Oh my gosh, so many names. Let's see, people. So people who are active researchers today in my own field, Cynthia Breazeal, Brian Scassellati, Holly Yanco, so that's in human robot interaction. Then we have researchers in vision like Paul Viola. I mean there are just so many. I'm going to be rude and leave a bunch of people out because – many of us are still in touch. People are either academics or they're doing research in some corporate lab, but I think most of us have hung onto that passion that we had.

Peter Asaro: Any other intellectual inspiration like theorists or roboticists that you sort of looked up to or modeled your career after?

Maja Mataric: Well, so when I was studying robotics obviously I was reading all of the work in the field in my Toto days, the navigation days, one of the major figures in the field that influenced my work was Ben Kuipers, and Ben had done the original work on topological navigation, although in a simulated robot, but subsequently I got to know him, actually, and he's been a mentor for me throughout my career, and Ben is just an amazing, amazing person. So he's someone I would single out. And I just want to point out that recently we were at the stages of our career that I recently lost a potential Ph.D. student to him, and this was the one that I could get over. I think the guy made the right choice, but otherwise, no. They should come to me.

Peter Asaro: How many Ph.D. students have you trained?

Maja Mataric: So I've had a lot of students in my lab. I love a big lab. Again, I'm modeling that after my own Ph.D. experience. I have nine Ph.D. students who have received Ph.D.s from my own lab and of course have been on committees of many others. And then usually if you look at my lab there's a slew of people who are Ph.D. students, a few postdocs depending on the level of funding, and then a hoard of undergrads because we love to provide that research experience for undergrads, and we love their enthusiasm and dedicated hours of free or not heavily paid work. It's great training for them, and of course we help them go on to graduate school. So my lab usually has like 15 to more people in it at any one time.

Peter Asaro: And are most of your students working on robotics?

Maja Mataric: So I'm really, really fortunate that the Ph.D. students that have been in my lab who have graduated, all of them are working on robotics, and over half of them are in academic positions. They are faculty. So examples include Chad Jenkins at Brown University, Monica Nicolescu who's at UC – I have to say that again. Monica Nicolescu who is at UC – why am I having this problem? You can edit. Okay. Not UC but University of Nevada, Reno, okay. So

Monica Nicolescu who is at University of Nevada, Reno. Then we have Evan Drumwright who is at Washington University. I don't even know if this is interesting. Also Brian Gerkey who is at Willow Garage who started the whole player movement, which has now transferred into ROS, which is the major open source robotics programming infrastructure. So I've just been incredibly lucky, and I don't want to leave anyone out, but if I say all nine then just cut it. But I have been incredibly fortunate to have great grad students, and I like to think we're still in touch. We're buddies. Dylan Shell who is at UT Austin.

Peter Asaro: Yes, so part of what we're looking at is mentorship ____________ and stuff.

Maja Mataric: Oh, that's my big thing. I mean I think mentoring is fundamental, and I think it's really a pipeline. So it's really important to both be a mentor and serve as a mentor, so my students in the lab, the grad students are mentoring the undergrads, but they're also being mentored by the – the students in my lab who are Ph.D. students are mentors for the undergrads and then they're also being mentored by the postdocs and certainly by me, and then I'm a very hands-on mentor. So then I end up mentoring them through to their postdocs if they have one or their academic careers. Once you're an advisor you're really mentoring forever, so I love it when I'm writing tenure letters for my Ph.D. students and like letters for my former students who are applying or being nominated for awards. I mean you can't do better than that.

Peter Asaro: Yeah. So how did you get interested in human robot interaction?

Maja Mataric: So I got interested in HRI the same way that I think every advisor should be interested in things, and that's through students. So initially, actually Monica Nicolescu from my lab who was a Ph.D. student at the time had gotten interested in human machine interaction and human robot interaction, and so she came and talked to me about that as a potential Ph.D. topic. And then at the same time in a sort of strange cosmic alignment we were applying for a large center through the National Science Foundation, and while we were looking at a lot of different topics I was being urged to think about societal relevance of the work that we were doing, and I thought about what interested me in that space. There are many applications of robotics that are societally relevant, but the one that interested me turned out to be really related to human health, and so that ended up being HRI for human health, which then morphed into socially assisted robotics, which is what I do today. So one of the major collaborations I had that started back in those days of my early interest in HRI has been with Brian Scassellati, who works on robotics for autism, which is one of the things I do now.

Peter Asaro: But that interest started after your Ph.D.?

Maja Mataric: Fascinatingly there were all these wonderful students that I was in the lab with and they were doing things and I was doing things. And then many years later I realized, hey, we have these fundamental interests in common, and so I got interested in autism and started working on it after I knew Brian Scassellati, and it's been great now to collaborate, and Cynthia Breazeal as well. But of course I think a lot of it has to do with a common mindset. We sometimes talk about whether we were all brainwashed and so we all think about the world the same way, but really it's the self-selection. All of us chose the same advisor and the same philosophy because we have certain preferences and certain strengths, and that's why we ended up the way we ended up, and that's what makes us a sort of a culture that works well together.

Peter Asaro: And do you do ongoing projects together?

Maja Mataric: We do indeed. We're doing joint projects. We're doing – well, you know how it is. The first step is joint proposals, so we write joint proposals quite a lot, and we're actually very soon now going to have a joint workshop, a National Science Foundation-sponsored workshop that's going to take place actually at Willow Garage, which is sponsoring robot testbeds to help robotics research. So interestingly, even though robotics is a huge field if you look at, for example, the annual conference ICRA, which is just huge, or IROS. At the same time as a member of the community I feel like it's a small world and a really friendly world. So I feel like I know the people. We know each other. We like each other, and we're trying to push the field forward.

Peter Asaro: What do you see as the central problems facing human robot interaction?

Maja Mataric: So HRI is a pretty new field, and we're just trying to define now what really the computational issues are, what the central problems are, but there are some really fundamental issues that I think are easy to point out. One has to do with embodiment. So the fact that HRI is about human robot interaction in physical space whether it involves contact or not, our own work doesn't involve any physical contact. So it doesn't have to involve physical contact, but something about the physical presence and shared context is very powerful. There are interesting effects that happen when a human and a machine are sharing a physical context even without contact, and that's very poorly understood, so embodiment is a major challenge of HRI. Another major challenge is real-time social monitoring and understanding what the user is doing and then having a dynamic that the robot can control and influence so that it's really not a passive thing where the human does something, then the robot does something, or the robot must do whatever the human says, but rather there's a real interaction dynamic, and it has to happen in real-time –

<break in recording>

Maja Mataric: – and that's a real challenge. And then there's another very interesting challenge in HRI, which is adapting to the user because the interaction really won't work unless the robot can adapt, and that adaptation may have to happen over a very long time scale. So as we look at application domains where the robot might be in someone's life for years on end how that adaptation works is fascinating. I mean, you know, half the marriages fail, so clearly it's a big challenge to adapt to people over a long-time scale, but it's truly fascinating. And that's just a snapshot. There are many other areas. I mean there are going to be, I don't know, thousands of HRI dissertations in the future with lots of great work.

Peter Asaro: What do you see as some of the central problems for distributed robotics systems, which is your earlier work?

Maja Mataric: So when I started out in distributed robotics back in the nineties – <whispers> wow – it was not a very well organized field. It was pretty new and ad hoc, and usually what people do in new fields is they try things. They do algorithms, often very greedy solutions to problems just to get the first solution. And one of the forces that actually I think helped the field a lot was robot soccer because a lot of people were interested in seeing robots play soccer in real time in some interesting and robust way, and so people came up with a lot of algorithms, and then as the field matured people started to understand the more theoretical and formal properties of those algorithms. And as things became more formal and solid that's about when I left the field <laughs> and I went into HRI, not because I don't like it. I think it's great. In fact, one of my Ph.D. students did a really nice formal thesis on this. And in some sense I feel like it's almost closure. Now you can really start to do scalable clean solutions to multi-robot control, and I think that's where the field is now. There are really interesting areas like auction-based algorithms and all sorts of issues on how to make distributed control scalable. A major challenge in distributed robotics is the lack of small, cheap, affordable teams of robots, and so it's very hard to do experimentation. And that was one of the reasons that I got out of the field was that it wasn't clear how we could make a difference in the foreseeable future. Where were the teams of robots? Where were the teams of light, affordable aerial vehicles? Where was the smart dust? Where were the bots? And without that you really couldn't validate, but it's coming.

Peter Asaro: What was your strategy and approach when you were writing your dissertation?

Maja Mataric: So when I was doing distributed robotics, again, back in my day, for my own dissertation I was really interested in local algorithms, so what people had thought about back in those days was looking at provable centralized algorithms. So you could say if you had a centralized controller and you could plan ahead and figure out what each robot, kind of like each agent should do you would do that and then you might reiterate. Of course that doesn't scale, and with 20 robots there was no way to do that in real time. It's not an issue of processing. It's just that there's too much uncertainty. The centralized control is too brittle. So then when you look at distributed control then there are all these issues that come up about partial observability and uncertainty, and is the solution actually going to be merely greedy? Is it going to be provable in any way? And so that was very interesting. So I was one of the early people that looked at local algorithms for distributed control. Subsequently people have looked at local algorithms, distributed algorithms, auction-based algorithms. One of the theses out of my lab was actually on auction-based algorithms. These are very promising new directions. And so the field, again, has matured from where we were, but it was a great place to be at the time. It was good to kind of get it started.

Peter Asaro: And similarly for navigation what were the central problems of navigation that you were facing in your day, and what kind of breakthroughs have changed the field?

Maja Mataric: So navigation is a fundamental problem of robotics. I mean if you can't move around without hitting things you can't do anything. And that was the first robotics class that I ever took, which incidentally was not from my advisor but was from another very senior faculty member, Tomas Lozano-Perez at MIT, and we were all intimidated by him. So when we took his class we all had to pick a project. And you basically could do manipulator robotics or in _______ schematics and dynamics, or you could do planner navigation. And so I did a project on a planner navigation, and that's what got me thinking about the problems there, which are sort of the standard known problems. There's a lot of uncertainty. The robot has a partial observability of the world. How does it move without being too slow and too sluggish and stop and go locally as well as toward some global goal? Those problems haven't gone away, but now "N" years later for a sufficiently large "N" <laughs> we have SLAM. We have I think so many algorithms in navigation that if there's one thing in robotics that you would get many of us to say is solved it would be navigation. So that's great to know. It's great to see that the field really maybe has not quite closed a chapter, but come on. We can navigate autonomously in an urban setting. We can send robots from L.A. to Las Vegas. It's pretty impressive.

Peter Asaro: How did you become interested specifically in autism as a sort of assistive form of robotics?

Maja Mataric: When I first got interested in human robot interaction for health, and immediately when I got interested in HRI I was really interested in the health context, I looked around to see where I could actually make a difference sort of in the near future, like where was there a niche where people wouldn't start to ask immediately, "Why a robot? You know, why bother with this?" And autism was a very natural niche because there was already anecdotal evidence that showed that people had put simple robots with children with autism, and the children tended – not always – but they tended to be interested and they tended to sometimes do very wonderful and unexpected things like show a social response that was otherwise missing or latent. And so there was already anecdotal evidence that this was a promising area, and there were a couple of labs that were working in that direction, namely Brian Scassellati's, so that was very inspiring. But fundamentally for me the inspiration for socially assisted robotics in general has been where can you make a difference? And when you see these kids interacting with robots and acting in a way that others judge as therapeutic and beneficial, well, that's all I need to know. Then for me that's enough. That's what makes it interesting. So it's not just the scientific curiosity, but it's the fact that it might actually improve someone's quality of life. That's why I've been interested also in socially assisted robotics for stroke because we have found that stroke patients are very receptive to working with robots in exercising and they do longer on the task with a robot than they do with a computer or some other interface. We have also worked with people with Alzheimer's, and who would expect that a person who is over 80 years old who has never seen a robot would really bond with our robots and improve actually on a task at stage two Alzheimer's, which is pretty serious, so dealing with people who are institutionalized and yet having them bond with a robot and report things like, "Oh, my buddy's coming tomorrow. I don't want to go shopping to miss my buddy." And these people don't go shopping. They don't even leave the building. So it really has been just for me heartwarming and encouraging to see that there are a lot of beneficiary populations for socially assisted robotics and for HRI in general, and now of course we have to do the hard science of making these robots safe and useful and either improving health outcomes or at least improving quality of life, ideally both.

Peter Asaro: And so what kind of humanoid robots do you use, and how do they fit into the applications?

Maja Mataric: Well, there's always this limitation of never having enough robots or never having the right robots, so because the United States doesn't really have a robotics industry as yet – I mean we have iRobot and we have a few other smaller companies, but we don't have exactly an industry of commercial robots out there on the consumer market, and as a result you can't just go to the store and buy a few robots and play around with them. So as a researcher we're always limited to a few different available platforms. Either we develop them ourselves – so we have in my lab worked on developing platforms, and we have a Bandit platform that we have used historically that we developed. There it is. Here's Bandit. The problem with Bandit as with any platform that was developed specifically for lab use is that it's not as robust or optimized as it could be. There are also commercial products that we used such as the NOW, which is more robust and more optimized, but then it has other features that I might want to change. Like I love it but I wish it were slightly bigger in order to have more of a peer interaction with the user rather than sort of almost a toy interaction. It's great for kids, but it's not good equally for adults. And then of course there's the Willow Garage PR2. The PR2 is an amazing robust platform, so there's a company that really did it right and I love it, but it's not a great HRI platform quite because it's too big and scary, so I like something that's smaller. You know, ideally 0.75 percent of an average human height, that's what we would like to go for, so here's my pitch to Willow. Come on! Make a smaller, friendlier, cooler looking robot for people. So I think in general roboticists today are limited by what robot platforms are available, and that hasn’t changed. That’s been the case for the last 20 years, and I’m hoping we’re looking into a future where we’ll have more options because that will accelerate research.

Peter Asaro: Do you think it’s even harder for humanoid robotics than other kinds of – like if you’re just interested in mobile robots or aerial robots?

Maja Mataric: It’s certainly harder to get a humanoid platform or to get the kind of humanoid platform that you want than it is to get a mobile robot, although it’s not the case that there are 50 different mobile robot platforms out there. There are just a few, a handful, but there aren't even that many humanoids. In Asia there are more, but it’s often difficult to get them in the United States, and that is a major impediment to research as well, so that also needs to change. It’s interesting to see where the niche of humanoid robots will end up because I think a lot of research needs to be done to understand that, and to understand it we need lots of different platforms to work with. It’s not clear that we will need humanoids in all areas of HRI, but we don’t know that until we study it.

Peter Asaro: How much of HRI is made up of engineering problems and how much are cognitive problems?

Maja Mataric: Well, HRI is I think fascinating in large part because it’s so interdisciplinary. I mean in order to understand the “H,” the human, you need social science, cognitive science, neuroscience. Oh, gosh, and then also ethics comes in. Sometimes things in health come in for people who are working in health such as my lab, so it’s incredibly interdisciplinary, and sometimes the boundaries are smeared and it’s hard to tell. People will often tell us, “Wow, you’re really doing social science,” and, okay, that’s fine if that’s what it takes. It doesn’t really matter what you label it. I think in general any interesting problem these days, any interesting hard problem is going to be interdisciplinary, so I think that’s the appeal of HRI is that you are doing many different kinds of sciences at once. But HRI is also difficult for graduate students because the grad student has to have enough knowledge of the different relevant areas. So for example in my lab the grad students have to not only know robotics, which is computation and programming and hardware, which in itself is hard and historically was hard enough. Now suddenly they need to know about proper experimental design, human subjects interactions, getting institutional approval for human subjects, the ethics of working with human subjects, analysis of multimodal data, video coding, so they are amazing experts by the time they’re done.

Peter Asaro: And are you finding that it’s harder to find students that have those skills that are ready to come into your lab, or are there more and more students ready for interdisciplinary work?

Maja Mataric: I find that since I'm doing socially assisted robotics it's even easier to get grad students, and I think it has to do with the relevance to societal problems, that people basically understand very readily that if they do this the impact could be in stroke, in autism, in Alzheimer's, and a certain group of people really find that appealing, and those are the people that end up being attracted to my lab, so that's a meeting of the minds. Historically when I was working, for example, in distributed robotics students would come in and they would be very interested because it's an incredibly interesting problem from the perspective of computation and robotics and theory, but then they wouldn't necessarily see where that would lead practically. Like will these robots ever really exist, and what will they be used for? And people start to worry about what some of the applications might be, whereas there's less of a worry and more of a clear path with socially assisted robotics.

Peter Asaro: What other areas of applications do you see growth for HRI and robotics in general?

Maja Mataric: Well, I think HRI is huge. I mean obviously I'm biased, but I think the whole notion of putting people and robots together is the ultimately interesting challenging problem because we finally have the hardware and the computation to make that possible. We can hopefully safely and interestingly put humans and robots together in close not necessarily contact – like I say, they don't have to be in contact. But interesting things can happen. Interesting social dynamics can happen. Interesting interactions can happen in terms of physical interaction as well. So for example I talk to people who work on physical rehabilitation or robot surgery or all these issues that are also HRI in a way. I mean they're human machine interaction in a very close physical contact, and then you have the social interaction, which is the side that I'm on, and all of those are incredibly hard, incredibly open ended. Like I said, it'll take thousands of dissertations, and that's the future. If you want to think about service robotics, robots in people's homes, robots in people's lives, robots in hospital, or robots that are more than just these passive things that deliver trays or monitor for people intruding that's all HRI.

Peter Asaro: So when did you come to USC? What was the robotics lab like when you got here?

Maja Mataric: I came to USC in the fall of 1997, and at that point George Bekey, who had founded the robotics lab at USC, was still running the lab, and it was wonderful to come here, actually, because there was an established robotics lab. There was an established interest. Of course, when I first came in the space that I got had a giant sort of sand pit because they were doing space robotics with a jet propulsion lab who were great and I collaborated with them, but I did not want a sand pit in my lab. And imagine the notion of sand and robots together, not so good. The gears, the sand, the oil, no. So we had to strip the whole sand pit out and get rid of it, and there was a big backdrop of space that had to be _______ and an image of Mars that had to be gotten rid of. So in a way it was great to come into an existing robotics context because I didn't have to fight the culture to explain why I needed space, why I needed all this stuff, and at the same time obviously you come in and you change the culture. You turn it in your own way. So George was a wonderful, wonderful mentor for recruiting me. And then I immediately teamed up with Gaurav Sukhatme, who is not in HRI but is one of the wonderful robotics researchers who works now on basically sensor actuator networks, so the whole notion of basically ubiquitous computing in any environment whether it be in the ocean, in the air, in your house, and we historically did a lot of joint work, and so I'm hoping we'll reconnect. But we share a lab, and it's been great. And then of course there are other researchers at USC. Stefan Schaal came the same year I did. We were hired – wow, how many universities hire two roboticists in the same department in the same year, so kudos to USC. And we've been at the same department ever since, so I think it's been great. I mean there's a real critical mass here. Wei-Min Shen working on space robotics, Peter Will working also on reconfigurable robotics, so it's great to be in a place where there are enough of us, a lot of us doing different things.

Peter Asaro: So you'd say the robotics faculty has grown since '97?

Maja Mataric: The robotics faculty as USC has definitely grown since '97, and we're still hiring and we need to hire more. I think we're not at a scale now, we're not like Carnegie Mellon that has many faculty or multiple faculty in the same area of specialty. So I think we have excellent people in their individual areas, and I think we need to grow more, I think it's safe to say. But it's really great to have both the robotics colleagues but also the interdisciplinary colleagues, so for my own work what really matters just as much as the robotics context is the fact that for my work in autism we have the expertise in autism. We have Children's Hospital Los Angeles that collaborates with us. We have the body of families that we can draw on for participants, and it's similar for strokes, similar for Alzheimer's. That's really what makes it possible for us to validate the work.

Peter Asaro: What are some of the labs and institutions that you're collaborating with?

Maja Mataric: Well, robotics, it's kind of a small world even though, again, there are so many people, but there are certain institutions that have the critical mass. So the largest ones obviously are Carnegie Mellon and Georgia Tech, and I've collaborated with people from both of those over time. Obviously I'm partial to my colleagues at MIT, but that's just – some people never leave and then we have similar philosophies. As I mentioned, Brian Scassellati at Yale, so those are some of the obvious examples. But I think collaboration, it changes over time, so wherever an opportunity arises either we will be contacted or we will contact people. For example, right now I'm on a large collaborative grant that involves USC, UPenn, Carnegie Mellon, MIT, UT Austin. I mean it's just huge, and that's great and there's all great people. There are lots of great people everywhere.

Peter Asaro: What do you see as the big robotics centers across the U.S. and around the world for research these days?

Maja Mataric: Well, so in terms of the robotics critical mass robotics is expensive just because it's experimental and it takes a lot of platforms, and platforms are hard to get. So I think places that become focused on robotics research tend to grow or stay where they are, and it's hard for newer places to develop a large robotics program, so if you look historically at where the robotics work is done on a large scale that hasn't changed. It's historically been Carnegie Mellon, MIT, Georgia Tech, UPenn, USC, and then there are excellent smaller programs in many other places. Obviously there's great work in robotics going on at Stanford, but if you look at the numbers of people you'd be surprised that some of the very elite programs in robotics around the country are actually relatively small, and that's fine, too. You just have to have enough people. It's very difficult to be the single roboticist anywhere because you need so much infrastructure whether you're one or ten, and so it's very difficult to be one, but three will do great. So there's great stuff going on there and also obviously there's robotics going on at Caltech that's great. There's robotics at University of Washington, Seattle, I mean everywhere. I don't want to even leave people out. I was just talking to some folks at Vanderbilt who are doing robotics for autism as well. So I think it's becoming larger, and obviously we're going to see more robotics as robotics becomes more a part of the culture. So I keep waiting for that consumer market robotic product after the Roomba, maybe something in the health space, that will actually sort of open people's awareness up to the potential of this technology, and then I think we'll see many more programs.

Peter Asaro: Why do you think there are so few commercial things like the Roomba and businesses and industries trying to get into it in the U.S.?

Maja Mataric: The answer to why we don't have more consumer robotics is very straightforward. Entrepreneurial efforts in this country fail at a larger than 95 percent rate. This is well established. It's very hard to be an entrepreneur. It's risky. It's pricey, and if you're not in the sweet spot of where the funding may come from, and if the economy is not good the odds are very, very poor. And so robotics, first of all, it doesn't have an established consumer market to begin with, so to sell this to let's say a venture capitalist is very hard even though the promise is there. And also there is no federal support necessarily for this other than the small SBIR programs. Right now there's a relatively new cross federal agency SBIR, which is a small business program, so maybe that'll help. But in general if you look at the robotics field in the United States compared to, let's say, Asia, Korea and Japan in Korea and Japan there's a lot more entrepreneurial effort in robotics because it's supported by their government. So they take less of a risk and have a lower barrier to succeeding, and you can see the results. So in this country many of us, say, older roboticists have gotten together and we worked with the whole field to put together the roadmap of robotics, so the roadmap of robotics sort of spells out the potential areas, which are all areas of obvious major impact including manufacturing, including service robotics, health robotics. I mean it's huge. And then there's been lobbying to try to convey to congress that there's great potential for our field, that it isn't just esoteric research with some toys, and I think it's starting to pay off. It doesn't help that the economy is not at its best because one doesn't typically innovate very well with a bad budget, but I think robotics has a great future, and we're starting to see that. Federal agencies are starting to kind of come together and carve out budgets. It's very political. You can cut it all. It's true.

Peter Asaro: So if there was a breakthrough that could revolutionize robotics what would that be?

Maja Mataric: Oh, gosh, a breakthrough that would revolutionize robotics. Well, you know, there's the standard answer is we need better sensing. We need better robots. Sure. I think that's always true. So when I think about, again, my own world, socially assistive stuff, we would like robotics that run longer, that have better energy supplies. The energy thing is very fundamental for putting robots and people together. That's not even a robotics problem per se. I mean roboticists are not even working on that. Much to do with robot skin and tactile ability for interaction, that, again, is a materials thing that needs to be developed, a lot to do with the manufacturing and the process of actually turning robots into being appealing and robust. So these are just practical things that I think most of our field if any is not even working on it. This is outside of our field yet badly needed. And then of course on our side of the world we're all grappling with how do we deal with limited sensing in robots that need to be safe and effective in real time. I think the problem of real-time interaction with humans is especially interesting because you're on what's called social time. So it's not like surgery but it's also not like playing chess. It's not an arbitrary time scale, and we still need to develop algorithms that can deal with that. So there's no shortage of both computational and physical problems, but I'm not worried about the computational stuff. I think I sort of understand that world. I would love to see more robots, better, safer, cooler physical systems.

Peter Asaro: What do you think the next big robot will be, self-driving cars?

Maja Mataric: Well, certainly self-driving cars are coming because if you have Google supporting an effort like that something good will come out of it. I think we need more platforms like the PR2 but smaller and for different uses. So we need more places like Willow Garage to develop robust platforms so that we don't keep doing one ofs in people's labs, and that will fundamentally change the world because then you can demonstrate that, look. Here are these robots for the hospital or for the school. I think it's actually interesting that there is now quite a surge of remote – what do I want to say – remote presence robots, this whole notion of remote presence platforms that maybe they navigate sort of safely and they can be tele-operated and they have a screen, and that's a start of putting machines in people's homes. Then you can kind of pull back from the remote control and have them become more autonomous. So I think those are the end roads we're making. I still believe that there's a huge killer app in the non-killer, non-defense zone of health, and I think maybe the way to go there is from simple platforms, Roomba like, that are cheap and affordable and safe because they don't do much, and then enable them to have some HRI capabilities, so that's my hope. Tell me what time it is because I'm getting a little panicked about being late for my own thing.

Peter Asaro: Yeah, yeah.

[recording ends abruptly]

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