

**Q:** Tell us your name and where you born, where you grew up and went to school.

**Danica Kragic:** So my name is Danica Kragic. I come from Sweden, but originally I was born in Croatia. I was educated there, both the high school and the university, and then I left Croatia for Sweden to do my PhD in robotics in Sweden.

**Q:** What was the university in Croatia?

**Danica Kragic:** The name of the university in Croatia is Technical University of Rijeka.

**Q:** Where did you go for your graduate work?

**Danica Kragic:** Wait now. What's graduate work? That's like my PhD, right? So my PhD is or has been performed at KTH in Sweden, in Stockholm.

**Q:** What did you study as an undergraduate?

**Danica Kragic:** Mechanical engineering.

**Q:** Is that also what you did...

**Danica Kragic:** Computer science for PhD.

**Q:** What made you decide to switch from mechanical engineering to computer science?

**Danica Kragic:** I didn't really give it too much thought. It came very naturally, so when I saw an ad it wasn't stated particularly that the PhD will be in computer science, because the center was an interdisciplinary center and included all different areas. It just by chance ended up to be computer science, but it did have a relation, because my high school education, it had been really in the area of programming and mathematics, so it was very, very natural for me to just basically go back to that.

**Q:** At what point did you discover an interest in robotics or artificial intelligence?

**Danica Kragic:** I suppose that I was always interested in machines or building, doing things and programming them in some way, but I really never thought about doing a PhD in robotics really. It just sounded interesting, so when I saw an ad for-- well, the announcement for the PhD positions by that time that was in like '97. I didn't do really any robotics research, but I felt that the background that I had in mechanical engineering and programming would be suitable, yeah, and I was right.

**Q:** Who did you work with?

**Danica Kragic:** So for my PhD at KTH I worked with Professor Henrik Christensen, who is now at Georgia Tech, and I also worked with Professor Jan-Olof Eklundh, who is in the area of computer vision.

**Q:** What was the project?

**Danica Kragic:** So the idea at that time was to equip robots with different types of visual capabilities, so the robot should be able to detect and recognize different types of objects and then interact with objects for the purpose of grasping them and manipulating them.

**Q:** What were the big challenges for that?

**Danica Kragic:** Oh, big challenges back in '97-- cameras, I would say. I mean, many things changed. Right now you just go and buy a very cheap 3D sensor that can do many things for you, but in '97 we just had regular cameras, and we couldn't process things in real time in the same way as we do now, so the problems are basically the problems that we are working on still right now in terms of doing, let's say, lots of dynamics, robots interacting with objects and so on. The same challenges existed then, but we couldn't do things as fast as we can do them now.

**Q:** Were there a lot of other faculty and students working in robotics then?

**Danica Kragic:** So the interesting thing was that when the Center for Autonomous Systems, where I was employed, was initiated in '96 the idea was to employ I think it was eight to 10 PhD students at the same time, and each PhD student got a project to work on, and that was really, really interesting, because-- well, from one point of view it was interesting because I was the only girl, and the rest were guys, and most of them were, if I'm not mistaken, Swedish studying at KTH, so I was like from a different country,

studying something completely different before I started computer science, and so it was a pretty large group, so eight to 10 PhD students starting at the same time.

**Q:** Was it challenging to be a foreigner and a woman in that context?

**Danica Kragic:** I think that the most challenging thing was that I was not used to the, let's say, working environment that they were used to, right? So they were all studying at KTH before. They knew how to use the programming environment and everything. It was like completely normal to them because they used to have it in their courses, so that was new to me, plus the language was also new. I didn't speak Swedish, and some of the courses were given in Swedish, so that was also new.

**Q:** Who were some of the other students that you worked with while you were there?

**Danica Kragic:** So one of the students, who is now a professor at Georgia Tech, was Magnus Egerstedt, so he was I think also employed one of the first PhD students at the center. Another person was Patric Jensfelt, who is also a professor in robotics at KTH. Who do we have more? Some other people. I mean, some people are now also-- well, still at KTH. Maybe they were away for a postdoc or had a career in industry, for example, but then now coming back at KTH actually in my group. Yeah.

**Q:** What was the environment in robotics like in Sweden more generally at the time? Were there other universities and industries involved in it?

**Danica Kragic:** From one point of view I think that, I mean, having robotics research in Sweden, it came very natural having ABB, a Swedish company, one of the first producers of robots, and so on, but there had not been so much research at that time like in mid-'90s on, let's say, service robotics, and that was the idea for the center, starting with service robotics and making change there. So I think it was a good environment because originally we also thought that the industry will understand and that they will give us projects and that there will be more collaboration, but ABB at that time did not have so much interest in doing something that was in the direction of service robotics.

**Q:** What did you do when you completed your PhD?

**Danica Kragic:** Yeah, so that was in 2001. By the end of my PhD I was offered a position as a postdoc at KTH since the center basically continued to employ new people and so on, so there was definitely a need for senior staff, but I also wanted to do a

postdoc somewhere, so I wanted to go somewhere and get a little bit of understanding how it is to be in a different environment, so I did actually two things. The final year of my PhD I spent six, seven months at Columbia University with Professor Peter Allen, where we addressed some grasping-related problems and real-time, model-based tracking stuff. That was really interesting. So that was the first kind of like longer visit, and then in 2003 I joined Johns Hopkins University and the group of Professor Gregory Hager, where at that time the big interest was on human-machine collaborative systems, so different types, so humans and robots or humans using robots to perform different tasks better, and their application was in microsurgery.

**Q:** And then you went back to KTH?

**Danica Kragic:** And then I went back to KTH, so I continued as assistant professor, and then in 2007 I think, yeah, I became a full professor. And I'm still there.

**Q:** You're still there.

**Danica Kragic:** Yeah, I'm still there.

**Q:** And you're the director?

**Danica Kragic:** Now I'm, yes, the director of the center. We grew pretty much. Now I think we have like 25 PhD students at a time and quite some faculty also.

**Q:** What were some of the robots that you actually used in your work?

**Danica Kragic:** So the first robot that we purchased-- and that was during my PhD-- was a PUMA arm, like a completely big, bulky, industrial robot, and the idea was to just test it for some pick-and-place tasks. And it was difficult, because it actually came with the original industrial set-up and the programming language that was designed specifically for that arm, and it actually didn't have any gripper, so we were just basically sitting in workshop and building something that looked like a paddle <inaudible> so that the hand could actually pick something up. So after that I think that we were actually one of the first universities that bought a big XR-4000 robot from Nomadic Technologies, and that was another challenge. So on that robot we put the PUMA arm on, and I remember that we were very proud, because there are like three PCs used for controlling different things, like the motion and the arm, and we used real-time Linux and QNX, so everything was on that poor platform that was moving around, and I think that at that time we didn't think

very much about that, but it was really heavy and dangerous. It never killed any PhD students, but, yeah, it was interesting, and there was something for everybody to do.

**Q:** Were there some others after that?

**Danica Kragic:** Yeah, so I think that we bought just about anything that we were able to buy if there was a good reason and it was needed in a project, because soon after we started with big European projects, collaborative projects, and in those it was very common to actually have platform that was available for all the universities, or each university had their own platform that were involved in the project. So what did we have? If I can remember right now, we had-- oh, I don't remember now the company that produced those-- mmm. Was it Active Perception? No, I don't remember.

**Q:** It's okay.

**Danica Kragic:** You will need to cut this. Anyway, but I should remember that, because we have four or five of those. It doesn't really matter. So what we did-- partially we were buying platforms from different companies, and we were also building things. So, for example, we bought lots of different parts, joint parts from **SCHUNK**, and we built a dual-arm robot where each arm had seven degrees of freedom. We actually had two set-ups like that, and then we still have them and can use them, and we also most recently then also bought PR2 and, yeah, I think we have most of the things that kind of, yeah, were...

**Q:** Mostly arm-based and then some other...

**Danica Kragic:** Well, I mean, we were as the lab always interested to do both mobility and manipulation, so it was extremely important for us to have robots that could do both, and there are not so many robots out there that can do good manipulation, so in terms of that the arms are small enough so that the robot can do navigation and **SLAM** and everything that we want it to do but at the same time manipulate everyday objects, not something that was like toys or, yeah, small stuff that you would have specifically for research purposes, but we wanted robots to really interact with the everyday objects human do.

**Q:** So you mentioned some European collaboration projects. Can you talk about who you worked with and what the projects were about?

**Danica Kragic:** So I can take the first that I coordinated. So these projects are pretty big. They're on the level of, let's say, \$1 million or-- no, more. Let me see. I need to...

**Q:** Euro?

**Danica Kragic:** ...convert everything. Yeah, no, it's more than that. It's like 8 million euros. What is that in dollars? It's approximately the same, right?

**Q:** Yeah.

**Danica Kragic:** Yeah, because a bit more, \$10 million, so that's why I'm saying \$1 million did not sound well. So, okay, we cut there. Anyway, so these European projects or collaborations between several different European universities, and some of them also include companies-- so one of the projects that I coordinated was called **GRASP**, and naturally it had the main topic of equipping robots with different capabilities to interact with objects but also to learn from humans how humans manipulate and interact with objects in their everyday life. So that project was started in 2008, and I think it had a budget like \$8 million for four years, and apart from I think it was six or seven university partners we also had a company, which is **Otto-Bock**, and that company produces intelligent prostheses. In particular we were interested in hands, so part of the project addressed the problem of how could we understand from humans which fingers are important, what is that humans do with their hands in everyday life and how can we then build better models for actuated prosthetic hands. So apart from then that company we also had Ludwig Maximilian University from Munich and Professor **Heiner Deubel**, who was especially interested in looking into humans, so he's psychologist and looks into how humans use their ocular motor system in interaction with hands to interact with objects, and then several other universities like **Karlsruhe** Institute of Technology. We had the **FORTH** Institute from Greece, from Crete. We had Technical University of Vienna. We had a Finnish university, Lappeenranta University of Technology, and then KTH.

**Q:** One of the things we're interested in is funding. I assume this is a European Union grant, but could you talk about how you coordinate with different labs around Europe?

**Danica Kragic:** Yeah, so getting money for robotics research, I mean, one would think that it will get easier, but it gets more difficult, and I think that the reason for that is that there are more and more people doing robotics and also that robotics seems to be an integral technology for many other areas, so sometimes it's not so very clear what's robotics and what's not, what's something else. So in Europe we have definitely done the possibility of applying for these collaborative projects, which I think were an excellent

thing for Europe, because it made it easier for each others, right, from labs from different countries to get to know each other, to get to know about each other's research and also to exchange research results, so I think that that is really, really excellent. So the calls that are of interest to roboticists, I would say that they come out only or almost on annual basis, and the acceptance rate is rather low. We talk about 10 to 20 percent, so it's difficult to get them, and it requires some work. I would say that that's negative kind of thing about having these big projects, because writing a proposal with seven other universities does take some time getting together, having all the meetings. And then also when the project is granted it does take some time to do all the paperwork, and you can't expect that all seven partners that participate in the project will collaborate with everybody, so you need to have a good coordinator that can identify who is to collaborate with who and when, so then the results can be really, really cool.

**Q:** And you have to compartmentalize the research a bit more when you have that many...

**Danica Kragic:** Yeah. I mean, it takes a bit of planning, and that's why I always say it's really, really important to have good coordinators of those projects that can push people, require things, and I usually say don't ever invite your friends to projects like that, because maybe at the end of the project you will end up not to be a friend to them anymore, yeah.

**Q:** Have you kept track of what's going on in robotics in Croatia and the former Yugoslavia?

**Danica Kragic:** Yeah, absolutely. I mean, I do have a good collaboration with the university in Zagreb and Professor Ivan Petrovic there, and they had several both national and international projects that they involved me in. The latest project that they had was really interesting one because it was more for establishing robotics as a field at their university, so they employed lots of young, promising people there.

**Q:** They were pretty early with the hand, the Serbian hand.

**Danica Kragic:** Yeah, in Belgrade, like former Yugoslavia precisely, they were one of the first building a robotic hand. It's a cool thing kind of like to look back and think about that now.

**Q:** How has robotics changed in Sweden in the time that you've done that?

**Danica Kragic:** So if I look back like these 15 years, apart from the area, really be getting bigger. Maybe we started at fewer universities. Now there are people doing robotics at several universities in Sweden addressing issues that are of different natures and have different application areas. I mean, we have people doing industrial robotics, people that are more interested into service robotics and use of robotics for disabled people, for elderly people, and then lots of developments when it comes to forestry, for example.

**Q:** What was the experience like when you were at Columbia?

**Danica Kragic:** It was a good experience. I think that-- well, this was like the first longer visit that I did, and it was also away from the group. I mean, for three years I was doing my PhD in a group that-- it was like lots of colleagues, like eight other PhD students. We were taking courses together, we were programming together and so on, and then you leave, and all of a sudden you are in a new group. And at that point there were not so many PhD students working on the problem that I was working at. I collaborated with Andrew Miller, who is now in Google, if I'm not mistaken, and, yeah, we had lots of fun. It was a little bit of a challenge, because I think that he was doing his practice or something like that in Philips or something like that at that point, so he needed to commute to his job every day, and then he would come to work in the evening, and so I had really, really long days, but it was really, really interesting, because I could attend different talks. The robotics group was also very close to both the graphics group and the computer vision group of **Shree Nayar**, so I had lots of interaction with people that were doing very different things, and I think that for every PhD student it's really, really important to broaden their views while they're doing their PhD, because if you just concentrate on one topic it's very likely that-- maybe you will become very good in that, but as soon as you search for a postdoc you need to write a letter of motivation, how you can do something more, and not everybody understands that on time, so I was lucky that I got the ability to do that or the possibility to do **that**.

**Q:** In the time you were at Hopkins you **sort of** left grasping and went to collaboration.

**Danica Kragic:** Yeah, so, I mean, it was not a completely new area, because the topic that I was supposed to work on was task sequencing, so part of the things that I have done in my PhD was on that topic. So, let's say, for robotics to open a door, how would you sequence that task? The robot first needs to **detect** the door, it needs to approach the door, it needs to **detect** the door handle, it needs to visually servo the hand towards the handle and so on, so a part, again, of my PhD addressed this task specification. And then Professor Hager, who was actually an opponent on my PhD thesis, so he was in my evaluation committee, saw a part of that work and said "Well, you can take this kind of



like task decomposition or this task decomposition thinking and apply it in a microsurgical setting." So the work was really only about how would we develop a system that would do some form of a task decomposition. That was the work.

**Q:** What were some of the other projects that you've done at KTH over the last few years?

**Danica Kragic:** So many. One of the more recent one that just ended last year, it was called TOMSY, and it was concerned with how do we use different types of topological notions to design motion planning algorithms for grasping, for example, and how do we address some of the difficult problems in terms of uncertainty and unsafe systems to achieve then robustness. So that was the one that I liked a lot because we worked with mathematicians, so it opened I would say a completely new way of thinking of how we could do things and mathematically modeled them, and that actually now ended up also in writing a new proposal, and that was just financed. That will start next year, which is financed by the Swedish financier. It's Knut and Alice Wallenberg Foundation, which includes then a way of thinking. So how could we use different types of, let's say, mathematical techniques to understand that, I don't know, writing it with a pen is very similar with using some tool to mix a soup? How does the robot understand that? How does the robot model that? How does the robot hold a pen or that tool in a similar way?

**Q:** Other projects?

**Danica Kragic:** Other projects. Let me see what we have more. Yes, one of the projects that we would like to actually-- yeah, we would like to give it a little bit more attention, but it requires collaboration with people that are not yet, let's say, skilled in using robotics technology, and that has to do with developing systems for elderly and developing system also for disabled. So there are different types of robotic appliances that we are thinking about here. It can be systems that are really not completely autonomous and mobile but systems that just remind people that they need to take medicine or help them to, let's say, move about in the environment or systems that are completely kind of, well, boring robots, you know, that solve logistic problems such as delivering medicine or just carrying around food, and this is more like then interaction with medical personnel in terms of they letting us know what is that takes time for a nurse. Is she running around just fetching things all day instead of sitting with patients and talking to them? It would be much, much better if she has a robot that follows her in her daily work, and every time she needs to kind of fetch something or inform somebody about something it would be a robot doing that. So in industry we talk a lot about third hand, so having a robot that interacts with a human worker and helps a human worker when there is a need for that.

This would be a system or a logistic system that would help a nurse to, well, run instead of her and do some of the errands.

**Q:** Any others?

**Danica Kragic:** I'm thinking of my list. Yes. One of the recent projects that we also started at KTH that Professor Patric Jensfelt, who is in the group, is responsible for, it's called **CENTAURO**. It's a European project, so building a platform that has legs and an upper part looks like a **centaur** that is used for, let's say, remote control in sending a robot platform out at a **terrain** that is difficult or dangerous for a human to be at but then that platform being really tele-operated by a human that wears a suit like an exoskeleton. So instead of, let's say, having a remote control, which might be very unnatural to understand how to control a robot's motion, you wear a suit then, and you move your body. Good for training too.

**Q:** Have you gotten more into haptics and things through that?

**Danica Kragic:** Yeah, there are a couple of projects that we have that are partially haptics but mostly multi-sensory integration, so haptics **forced-work [ph?]** vision, and the idea has always been that having several sensory modalities can only help and to some extent also maybe mimic biological systems or get inspired by biological systems to implement, let's say, a multi-sensory robot system, and the idea is that robots can visually then or with laser detect objects, but the interaction is then fully force or tactile-based. The interesting thing there is how do robots get more information about the environment or the robots through touching, so that's one of the things that we have been recently working on a lot. How do we build models? How many times does a robot need to touch an object to understand its geometry? And then more interesting things, that it's not only geometry but what's in the package. Can the robot understand how much of the milk there is left in the package or whether there is like coffee or flour in a package? And all of that can be done through tactile sensing. It's not easy, but yeah.

**Q:** Can you talk about the problem of complex, dynamic, cluttered environments and grasping and manipulating within those and how the multi-sensor really helps that **situation**?

**Danica Kragic:** So robots working in actual environments that are dynamic and commonly changing, yes, it is definitely a challenge, and I think that this is one of the big reasons why we don't see the deployment of robots in service-type of applications as we maybe hoped. And there are many challenges apart from things at our homes not being

very structured and also homes being very different. Just the understanding of how different homes can be, that's still something that we need to do a little bit of research on. A couple of years ago at KTH, we had this project that was-- oh, it's still up there and we encouraged people to take their **Kinects** and just scan their kitchens and their living rooms and upload the data to the site where we could then build 3-D models. And the idea was to have all these models of living rooms and kitchens, just to understand how different these rooms can be. So that's one of the challenges. So, first, understanding what a kitchen may look like or what a bedroom can look like. Once having the models and using them for all sorts of different things, it's another challenge. So how do we understand where objects are commonly placed? Just understanding the whole statistics of natural scenes. So how often is there a pen on the floor and how often is on the table? And not disregarding the information that is not very, let's say, common. A pan on the floor maybe happens in 1 to 2 percent of cases, but it might be really, really important in case if you have a toddler at home and you want the robot to signal, "Oh, there is a potentially dangerous object on the floor," and robot goes and picks it up. So apart from, as I said, generating and collecting all the information of how things may look like in our homes is also defining the problems that we wanna address. And those problems need to be of interest to the end users. So if we want them to buy robots and use them in their, let's say, daily lives, we need to motivate it well. We need to say that, "Well, it's not only about cleaning. It's about making your homes more safe."

**Interviewer:** Great, and could you talk a bit more about where you've gotten funding and if you've collaborated with industry **and so on?**

**Danice Kragic:** So the funding that we have at the center, a big portion of it, of course, comes from the European Union. And we try to be really careful there because you can't have too many **EU** at the same time, otherwise it's too much **travelling** and too much administrative overhead. So we try to balance that with some of the national funding and in Sweden, there is a Swedish Research Council that finances basic research. And one may wonder is robotics really basic research or is that applied research. But I think that still there are many, many questions in robotics when it comes to development of, let's say, mathematical techniques for encoding all the data and all the knowledge that we can extract. That's very much basic science. So Swedish Research Council has been financing some of our projects and then we have **two** more foundations or agencies that are more, let's say, focusing on financing applied research and, at the end, research that is so close to, let's say, industrial application or product development. So that with their help, we could also, let's say, have different startups or close **collaboration** with industry. And these are foundations for strategic research in Sweden and **VINNOVA**, they are called. And in these projects, yes, we have been having collaboration and have current collaboration with companies such as **ABB** and Scania. The interesting thing is that, during the past couple of years, we have also have some startups. So I would like to mention **Volumental**, a very nice, young, agile company that is all about 3D scanning.

And I think it's really, really interesting because applications they are talking about is like I would scan my feet and then I would find the perfect shoe that matches my feet or perfect clothes that matches my body. And people often ask, "Will robotics generate new jobs? Will there be"-- and I say, just ask my husband. Maybe it exists. I don't know of it. Ten/fifteen years ago, we had these companies or shops where you could go and copy a bunch of papers and things like that. Those almost disappear today. But I think we'll have places where you go and scan yourself and, if you gain some weight or if you lose some weight, you'll potentially will need to scan yourself often. Partially because there will be companies then selling fitted clothes and shoes and all different products based on, let's say, how you look. But maybe also for medical reasons. So I think that we haven't yet seen a complete development of that field. I think that's gonna be big because the companies that are just now selling clothes to **an** average x, they, I think, will start to look into how they can start to sell fitted clothes. So they will need much more personnel to fit that clothes to you and will get it home. So you will not need to take care of that yourself and fit it yourself to you. And I also think that there will be, then, also different types of medical appliances and so on, maybe things that we need that ease the back pain or something like that. It will be much, much easier to sell to individuals, if they have your body model.

**Interviewer:** Is that a startup that you've been involved with personally?

**Danice Kragic:** It has been my husband so I know a lot about that but the PhD students that-- they have started a company. Some of them have been financed by the projects that I have gained work, got.

**Interviewer:** Have there been other startups that you've been involved with?

**Danice Kragic:** Yeah, we had a couple of others that one of the startups. It was bought by a bigger company and I forgot the name. Part of the work that we do is on image-based processing. So the company looked into how we could develop a system for having the bus tickets and train tickets on your phone. So it was basically developing a machine that could just do a reading of any ticket on any bus or any train. And then also a company **OculusAI** that looked into, well, different types of images of individuals and looking into how we could use, then, digital image processing for retrieving or dealing with different types of information.

**Interviewer:** Who are some of the PhD students or post-docs that you've trained that have gone on to work in robotics?

**Danice Kragic:** So a couple of the first ones that I had, they went to industry. I don't know whether I was like a really tough supervisor in the beginning and I scared them off or they just saw. I was still struggling with my academic career. So maybe just say, "Oh, the hell with that. I just gonna go and do something normal." Anyway, so Stephan and Daniel, both of them left for industry and they're doing really, really well right now. Daniel is at NAM, started in Intel and I think that he now changed but both of them have pretty high positions there in their companies. And two of the most recent ones that I'm really proud of are Jeannette and Javier. And both of them are at the Max Planck Institute in Germany, one of them working with Stefan Schaal and one of them working with Michael Black. And Jeannette was actually one of the students that accompanied that robot, the first robot that ever boarded a plane. I don't know if you know about that but she was one of those that...

**Interviewer:** Flew from L.A. to Frankfurt...

**Danice Kragic:** L.A. to-- yeah, precisely. So that was cool.

**Interviewer:** That's great. Could you talk a bit about your involvement with the IEEE and the service side?

**Danice Kragic:** Yeah, so I think that for everybody that is in the field, it's important to do some of the service work too. And I think that apart from building your network, it also feels good if you feel that you have given back something to the society. So I've been involved with the IEEE for a long time. I think that the first thing that I did was I was a chair of one of the technical committees on computer and robot vision. And it was really an interesting experience, because, during that time, I was in contact with many people that were doing research in this area and I could use them then as a reviewers, both at conferences. When I was the editor for some of the "ICRAs" and "IROSes", but also when I was associate editor for "Transactions and Robotics." So being involved gives you the possibility to build a network, to also meet people. And some of them are more serious, some of them are less serious so, when you need somebody to do some work for you, you know who to contact and you know who are the people that are going to do good job.

**Interviewer:** This is the first organizing committee that's been all women. What are some of the challenges for getting more women involved in robotics?

**Danice Kragic:** Wow! I think it's like in general, like in any technical area. There are not too many women and it's a challenge. I mean, I have a seven year old boy and now a ten-month old baby at home, and I'm here. I can wonder, "What am I doing here in US

now?". But I think that having kids and having the responsibility for the family, I think that that actually is a challenge, to balance that with your academic career. It's not like that you cannot travel or something like that. Just like in my case. I don't wanna travel. I mean, I want to see my kids developing. I want to spend all my time with my kids. So it's really, really-- it's a challenge from that perspective, that you all the time must balance who is more important. And I think that one of the reasons in general for making the academic career is that you actually need to do so many things at the beginning when you are still not the full professor, and that's exactly maybe also the time when you get your kids. So that's a big challenge and I think that many women feel like I do. They prefer to spend their time with kids and then you get too old. Or maybe not too old but you are away from work for too long and people forget about you.

**Interviewer:** Are there some initiatives of-- that's terrible. But it's totally true. It's true.

**Danica Kragic:** No, I can say more depressing things also so-- I mean...

**Interviewer:** <inaudible>

**Danica Kragic:** ...I'm just thinking like my son. He's seven and he's actually born with a very serious brain injury. So he's autistic. He's mentally-- so that was a real challenge because I felt that he can't speak or anything like that. So-- but from one point of view-- this is going to sound horrible but he cannot communicate his feelings well. So I was still able to travel and everything and I got lots of help from my parents and my husband's parents, who-- they were with him and so on. And I don't know. It just worked out and then we waited for a long time to get a second <inaudible> kid. I mean, I'm 43. I mean, you don't get kids when you're 43...

**Interviewer:** Who do you know?

**Danica Kragic:** ... if you're not a movie star. Anyway so now we got a second child. She's healthy and everything but she-- you can see that she needs you in a completely different way than he did and she communicates that. So I see that she's sad and see that she needs me. And there I think it's difficult for any mom, and for any dad for that matter, to kind of like travel and choose career instead of family. But I think, in general, that what we are fighting the problem, why there are not so many women, is that not so many women actually study computer science. This is where the problem starts. If you, for example, take Sweden. Most of the girls will go and study medicine or economics. How do you call that? I don't know. What's that? Yeah. So because there I-- and the reason is that, in Sweden, you get into the university based on your high school grades.

And for getting into the medicine or economics, you need really, really high grades. And girls, they're really competitive. So they want to go to places where they need to show that they are the best. In the computer science world, we get like 5 percent, maybe 10 percent of girls. Not even that. And many of them will leave if they on the way of being or finishing computer science, get a good job, and most of them do. I mean, we have problems with male students too and I hate that. I hate that companies employ them when they start to do their master thesis, because then they can pay them less since they are not kind of finished engineers. People just continue to work and many of them never actually finished their university education. Sad but that's where we are.

**Interviewer:** What do you think the society or the discipline could do to change that?

**Danice Kragic:** It is somehow always expected, partially from female researchers, to be good role models. We should go around and we should talk about robotics and about areas that encourage young girls to apply to study computer science and mechanical engineering and so on. Yes, we can do that and I think that the number may increase somewhat. But I also think that we need to be really realistic and that's not enough. I think that the society as a whole needs to think, "Okay, what are the future possibilities in general when it comes to new jobs? Where is it I can make a good career? How can I, let's say, if I have many different interests, how can I express those in a certain, let's say, area or at a certain job?" And I think that-- I mean, robotics is really, really wide. It has this perspective of being very technical but it has this aspect of helping humans and I think that many girls, women, like to do that. To do things that in some way can increase life quality and so on. And I think that if we talk about that often enough, then the girls may see that. Maybe doing medicine is the same as doing robotics. Because right now, when you say medicine coming out with new, let's say, medicine or really doing surgery on somebody and saving lives, that's important for many of the girls. And maybe we say, "Well, robotics also saves lives," then they will maybe think differently.

**Interviewer:** Great. The question we always wrap up with is what is your advice to young people who might be interested in a career robotics?

**Danice Kragic:** What I think is important is that they need to understand that doing career in robotics requires solid knowledge in very different areas. So, to some extent, people think that, "Oh, it's like playing with toys." It's not anything like that. You need to be really strong in mathematics. It's very good if you are also excellent in programming and many other things. So, if you can somehow design your education so that it covers all those different areas, that is what I think is important. And then you should also have a genuine interest in building things, because building things and programming things, it's really, really exciting when you see something moving. But it's also very frustrating

because things break all the time and it's not like that we are sitting in our rooms with paper and a pen and just do some creations all the time. It has to do really with integration of doing this theoretical research and applied research. And if people like that, then they will really enjoy having a job or a research career as a roboticist.

**Interviewer:** Great. Is there anything else that we didn't talk about that you'd like to?

**Danice Kragic:** Oh, many things but we don't have time for that.

<off topic conversation>

**Interviewer:** I do have one thing that I wanted to ask. It was something early on. When you mentioned that the group really started with a focus on service robotics at KTH, why pick service robotics?

**Danice Kragic:** I think that the reason was that Professor Henrik Christensen and the other professor, Jan-Olof Eklundh, they understood that there was a gap. There was nothing like that happening in Sweden and-- but there were notions of these kind of aspects happening in Europe and in U.S. So I think that it was a very strategic kind of way of thinking and planning very early then. That was one reason and I think that Sweden is a very good country to address these problems at because we have, let's say, an environment or a society where it is very, very important that everybody has the right to the kinda like medical insurance, that our elderly are taken care of and that I don't necessarily need to be the person that takes care of my parents but that there is a society. That there is something that is organized in the country that can do that. And robotics appliances can definitely be one good tool towards, let's say, making even better in that area. Yeah, making things better.

**Interviewer:** Is that still the focus and goal of the <inaudible>?

**Danice Kragic:** Yeah, I mean, to some extent, it has been maybe more difficult to get all the way through than we expected. Because people always say, "Well, I want a human taking care of me, not a machine." And I think that, partially, it's because of misunderstanding. Nobody wants to take human out of the loop. We just want those humans that are in the loop in helping other humans to have more time to help them, because we do get older and older. There will be more and more of us sitting in elderly homes needing help. And apart from us getting older, there are less and less kids being born. So there will be less and less humans that can take care of humans so we will need something else. That's one thing. And then it's also kind of like a paradigm or the



generation change. I think that the generations that will come after us, they will have much easier time of interacting and integrating with machines because this is what they do. From being born, they get used to use different kind of like gadgets. And the generation that is before me or like my parents and so on, they're not so used to that. So I understand that they are skeptical.

**Interviewer:** So after the digital natives will come the robot natives?

**Danice Kragic:** Yeah, well, everybody talks about "robolution" you know and that-- it will come at some point. It's natural. It will just be there. Now the question is how all the discussion about A.I. taking over will affect the whole field. But there is much more important aspect of the whole thing that is being discussed in Sweden right now, and this is using robots in the manufacturing industry. And that has to do with robots taking over more and more jobs. So the question is like will there be time when we don't anymore need, let's say, people that are not highly educated but that have certain skills. That they are not needed anymore and that, since they don't have good education, they cannot be maybe retrained or educated easily for more complex jobs. Now, an interesting discussion is how this is going to affect the, let's say, some of the decisions that government takes. Because all the companies right now, they pay tax to the state, dependent on how many employees they have. But let's say if it would change the whole thing and they would basically pay the tax to the state of how much they produce. That, I think, would be-- then it doesn't really matter whether robots do things or whether humans do things, because then a big amount would be coming to the state and then the state can use that money for further educating those people that don't have jobs or potentially doing things and decisions that could make us work less. Maybe only having four hours working days or something like that. That would be fantastic.

**Interviewer:** Yeah, a guaranteed income. Just stay home and make the robots solve it.

**Danice Kragic:** Yeah, but it would be cool. I mean, I think that in-- it will not be-- it's not that it's only gonna be normal but it's not going to be unnatural for more and more people in the future not working as much as they do now. I don't think that there will be need for that if everything is automated and that would be really, really fun. I mean, if you can just kinda spend time with your family, with your relatives and things like that. Not for the reason that you just have more time but also because we change our way of thinking and say that they feel better. If we meet more often, if we just spend more time together, we have a boost on our kind of mental development. And that's really interesting so everybody says that. That the development has been made, the technical progress that mankind has done, it's gigantic. I mean, we have developed things that our brains cannot even understand in a way, because our brains are still not as developed as maybe all the

technical things that we use. We don't know how it affects us. But, when it comes to art, when it comes to kind of like personal spirit development or whatever, nothing almost has been done. It's just that it has, to some extent, also been our health, in general, deteriorating. Like mentally because we are more stressed than we used to be and so on. So the question is whether we can use, then, this technical development to give us more time to do this other type of spiritual development and bla-bla-bla. But when I was thinking about that three or five years ago, I was like, "Oh, spiritual development. What's that?" That's like, "ha-ha." Nobody wants to talk about that. But I don't think that we can continue to be exposed to this very advanced technology that we still don't know how it completely affects us and so on without addressing kind of like this type of development of, "No, I don't want to answer my email all the time," or "My telephone makes me stressed," and stuff like that. We don't talk too much about that. And the robots will kind of like creep on us and-- scared.

**Interviewer:** It is good place to stop-- But you're right. My daughter who's three, she has robot-- she has a Roomba her house and to her it's normal. It gets stuck and then it's her job to find where the robot is.

**Danica Kragic:** It's completely okay if she starts to talk to it. If she talks about it. I mean, and if she says, "I love my Roomba. Can your Roomba do this?" And it's not like the same for the generation of our parents or something like that, to talk about things that are not alive in the way as they were alive. I mean, they had this way of thinking in Japan and Korea. But in Europe loving your robot or something like that, it's like, "Ooh." So I don't know if you know about it but there've been this-- Swedish TV has made **Äkta människor** show, Real People. Have you seen that?

**Interviewer:** Mm-mm.

**Danica Kragic:** So it's not a film but it's like several episodes. It's like a serial about a society where we have robots that look exactly like humans but are robots inside. Okay?

**Interviewer:** Kinda like **"Ishiguros"**.

**Danica Kragic:** Yeah, exactly like that. And they address some of the issues of how humans like that, that are very much against saying, "Okay, you're a human and I like you," bla-bla-bla. "But then, how scared I get if I would get to know that one of you is a robot. That I would never accept you," and bla-bla-bla. But they address this issue of how, as humans, we are easy to-- how easy time we have to actually just accept everything. So something that shocks us, something that we would say we would never

do, it takes us very little time to adapt. So and I think that that's an interesting aspect of us being humans, that maybe we are scared at first but, when we see that it adds something to the quality of life or something like that, we are able to actually accept it. So the acceptance aspect of the advanced technology. We may say that, "No, I would never do that or use that," but as soon as you see that that is actually to your benefit, no problem. And this is what they have been addressing, this kind of like clash between people that say no and then they see that something is okay. They have love stories about loving your robots and-- yeah. It's...

**Interviewer:** They're getting the public ready.

**Danice Kragic:** I mean, they're-- yeah. I think there are some issues that you laugh at because they have a USB way of kind of like getting the energy and everything. But there are things that are interesting too. Good.

**Interviewer:** Thank you.

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