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Katherine Driggs-Campbell

IEEE RAS Interviews

University Of Illinois, Urbana-Champaign
Assistant Professor
Electrical and Computer Engineering

Q1: Tell us about yourself.

Katherine Driggs-Campbell: I was born and raised in Arizona. My mom's family was born and raised in Arizona. We've been in Arizona for a really long time. But when I was going through high school, I actually had no idea what engineering was. And I was just sort of happily going through life, worried about when I was about to graduate high school. I told my counselor that I really liked math and physics. He said, "Oh, maybe you should look into engineering." And I'm like, "Oh, okay, maybe I should." So yeah, I just kind of picked one at random. I looked through the different engineering options and it seemed like electrical engineering didn't have too much chemistry and that's sort of how I picked it. So I got really lucky that it ended up working out okay.

Q1: Tell us about your college experience including mentors.

Katherine Driggs-Campbell: I went to Arizona State University for my undergraduate. And while I was there, I was very fortunate. I got involved in research very early. So there I worked on biosensors, actually. And I worked with professors N.J. Tao and Erika Berzani. And yeah, so we basically were developing these chemical sensors there. We got to actually do some pretty cool things. We took them to oil spills. We got to take them to different places of work and do some really cool things with them. So it was kind of a cool experience. But around my junior year-ish, I started thinking a little bit more about the different applications within electrical engineering. And I really decided I liked the area of controls. So this was sort of the area I wanted to go into, which was pretty different from the sensing world that I had been and where I had a lot of my research experience. But it kind of came together well when I started looking at different applications and what I could pursue for grad school. And robotics is kind of a nice intermingling of these two things where we had the sensing element. And then I was really interested in looking into that action control piece there. So it kind of connected well.

Q2: So chemistry after all.

Katherine Driggs-Campbell: I know, yeah, after I went, pushed hard to try to avoid it. And I ended up being surrounded by chemists all the time. Yeah.

Q1: What type of work experience have you had?

Katherine Driggs-Campbell: So relevant to engineering. So the first lab I worked in was this biosensors lab. So I worked there for three years. And that's where I was working on developing biosensors there. I did take an internship at Taser, actually. So I did a summer

developing some of the tips for Taser, which was kind of fun. A very different side of electrical engineering than I had previously been exposed to. After that, I went to UC Berkeley. That's where I was a graduate research assistant. That's where I did my master's and PhD. Let's see. I also worked for a little bit at MIT Lincoln Labs. So that's the national lab associated with MIT. And there I got to work on some decision-making for surveillance applications. I am currently an assistant professor in the electrical and computer engineering department.

Q1: How did you get interested in robotics?

Katherine Driggs-Campbell: So when I was applying to graduate schools, I was generally interested in control systems. And I knew I was interested in things that had to work with people. And it was kind of vague what that meant and what that was. And I didn't know too much about some options there. But I went to some programs that were meant to help people prepare for graduate school applications and visit different schools. And I ended up visiting USC. And there I saw a talk by Maya Matarek, who's a roboticist there. And she talked about these social robotics that she was working on. So she was working on these robots that could interact really well with people and help kids with autism and do all this cool assistive stuff. And after I saw that talk, I was like, this is it. So I was about actually halfway through my application process to graduate school. Like my research statement just totally changed. And I totally said, okay, this is what I want to do. This is sort of the perfect combination of the cool technology development and really impacting people there.

Q1: What was the first robot you came into contact with?

Katherine Driggs-Campbell: I think that Jetsons was probably my first exposure to a robot, but I don't know if it made a huge impact on me there.

Q1: What was the first robotics project you worked on?

Katherine Driggs-Campbell: So when I started graduate school, I immediately joined a project that was working on semi-autonomous vehicles. So this was right around, this is in like 2012-ish, and this was right around when the Google car, so pre-Waymo was, it was just sort of getting announced or leaked and whatnot there. So yeah, we started looking at how we can model driver behaviors to better inform decisions that a semi-autonomous vehicle could make. So it wasn't quite fully autonomous, but almost there.

Q1: What type of projects did you work on after that?

Katherine Driggs-Campbell: So my first project was working on this driver modeling for semi-autonomous vehicles. So we looked at how we could model human behavior and then predict what people were going to do. And that basic idea is kind of a common thread throughout all of the research that I've done since. So when I was at Berkeley, we extended this to say, okay, if we can predict a driver in the vehicle really well, we can expand this to other drivers. So we expanded this and we were able to apply almost the same exact techniques to autonomous vehicles. So we could expand this out and go from there. And then a lot of things that guided many of the next projects that I looked at kind of stemmed from that. So now that we have these autonomous vehicles, they interact with other people well, how do we make sure they're safe? So we looked at things like validation and kind of built up from there. So for the first few years, when I was in the Bay Area, there was sort of this nice progression of building up sort of the autonomous system stack and then doing some assessment and kind of building up that whole picture.

Q1: Tell us about any current robotics projects you're working on?

Katherine Driggs-Campbell: So since starting at Illinois, my lab looks broadly at how we can design autonomous systems that interact safely with people. So we look at a bunch of different contexts and applications to basically make that happen. So we look at how we can design autonomous vehicles that are safe and interactive. We look at how we can enable collaborative manufacturing. So how we can have this close coupling and close interaction between robots and people. We do a lot of work in social navigation. So this is more of the mobile robot space. So we look at how these mobile robots can interact with people at a larger scale. Also, since coming to Illinois, we have a lot of work in agricultural robots. So we do a lot of stuff with fields or mobile robots that go out in the fields and have to do things like report back to people. So we've been looking at some supervisory control, fleet management things as well. We've also been doing some stuff in assistive robotics. So expanding some of our work in navigation to move towards things like assisted navigation too.

Q1: What can you tell us about these agricultural robots?

Katherine Driggs-Campbell: In my work in agricultural robots, we take the stance that many of the current practices sort of assume that you have these really big pieces of equipment. So when I say robots in agriculture or an autonomous system in agriculture, people often think of like the big John Deere, like autonomous tractor-type stuff. And those are really good for operating at scale. However, there are lots of sort of issues with some of the current practices that it basically perpetuates. So it kind of, it promotes like spray and pray kind of culture. It actually has a lot of issues with compacting the soil. So this big heavy machinery going over the soil is actually pretty poor for soil health. They're actually also very dangerous. Actually, agriculture is one of the most dangerous industries in the US, mostly due to silos, but also due to the really large equipment.

So one of the stances that we take here is we work with these small robots. So these are the small mobile robots that are meant to go under the canopy. So we primarily work with commodity crops, since we're in Illinois, and they basically go up and down the rows here. So what this allows us to do is this allows us to start thinking about how we can transform the current practices to those that are a little bit more sustainable. So we can gather more information, so you get information about how the plants are growing. You can also get a more precise estimate of like where weeds are. So instead of spraying the whole field, you can either very precisely spray or even do some mechanical operations instead. So we look at thinking about how we can enable these small robots to operate well. So hopefully then we can apply them at scale. So instead of having one giant tractor that's going across the whole field and performing whatever applications or thing you need it to do, we can have a fleet of these small robots and go and do a bunch of different tasks and collaboratively work together to do what needs to be done on the field. And we collaborate with EarthSense, which is actually a startup from here.

Q1: What are the main research questions you're interested in?

Katherine Driggs-Campbell: So I'm really interested in thinking about what happens when you have humans and robots working together. So what is it that makes sort of humans collaborate so well together? What sort of intuitive things happen? What sort of modeling and understanding do people have when they're doing things? And how can we take some of those insights and translate them over to robots? So I'm really interested in thinking about how we can both model these human-human interactions to inform how robots should interact. And then I'm also really interested in this adaption that happens. So when you have a robot and a human interacting, it's going to be a little bit different than humans interacting. So what are some of those differences? How can we minimize them? But then how also should we change and adapt over time? So these are broadly the things that I'm very interested in.

One of the things I've become more and more interested in lately is also lowering the barriers of entry. I think often when we think about designing robots for interactions, you kind of assume you have people with some expertise or some insight to how things work. But I've been really interested in thinking about how we can make robots more accessible on all different levels. So making them easier to use and very intuitive. But then also seeing if we can design some new tools to help even non-experts sort of get involved and have a say in controlling their robots as well.

Q1: What challenges have you faced in your career?

Katherine Driggs-Campbell: When you're dealing with humans and robots interacting, I think one of the hardest parts is really making sure that your results are solid and valid in many ways. I think it's very tricky to run large experiments, do things at scale, make sure things are reproducible. And this is one of these things that often, as engineers, we try and make things that

work. And in academia, we're very biased towards doing things like proof of concepts and whatnot. So there's this kind of push and pull and trying to show something that works and then really pushing it to this point where you're really confident that it can work with people out in whatever settings and whatever happens in the real world. So I think there's been a lot of sort of push and pull that makes a lot of this research quite hard to do and very time intensive. Because as I said, when you work with people, you really have to do these user studies. If you don't have people there, then you might as well just be doing robots on robots there. So I think that's one of the big broad challenges is, again, this sort of push and pull with wanting to develop and also wanting to show that things work and also just the time commitment it takes.

Another big challenge I found is, often there's a push and pull also between academic research where you're trying to do something cool and innovative, something that no one else has done before. And you want to do high impact research and things that industry cares about. So if you start working with industry, you can start doing some translation and whatnot there. But that piece is very hard to do in the academic setting, I found. So really making sure you can do that translation and that you meet some of the needs of industry is one of those sort of tough challenges where I don't know if there's a good solution, but it makes it challenging when, again, you're trying to think about how can I take my work and make it have real world impact, but then how can I also do the cool academic research pieces there.

Q1: Have you had to to any translation between robotic disciplines?

Katherine Driggs-Campbell: As a roboticist, you tend to be a jack of all trades. You have to build up a complete system, even if you want to show something like, okay, if I'm working on a motion planner, I want to show that that works. If I want to put it on a robot, I need to solve everything that goes up into it to make sure it works here. So I need to get the perception system, I need to get the compute hardware work. But there's been so much effort in open sourcing material now that it's actually, a lot of these issues have gotten a lot easier. So when I first started as a graduate student, I remember I had to kind of bend over backwards to get around not having to do perception stuff, because it was such a big challenge to get things working there. I could spend my whole PhD just doing that when I wanted to do more of the decision-making side of things. But again, in the last 15 or so years, there's been so much push for open source and so much new hardware has been available too, that it has made that a lot easier, I think. So I haven't had as many issues translating between these sub-areas as much.

Q1: How would you characterize the differences between fields?

Katherine Driggs-Campbell: So I think the major difference is that in industry, you're driven by figuring out what will work, so you can turn this into a product. And you have deadlines, you can't just keep working on things forever. So you have a very clear goal and what you need that sort of product to be. When in academia, you're often trying to solve new and open problems, and you just wanna sort of figure out what works, but often you just kind of get that proof of

concept stage. So I think sometimes there's a sort of push and pull between academics and industry when sometimes that doesn't always align very well.

Q1: What tools have you used that have made a significant impact on your research?

Katherine Driggs-Campbell: So actually, the Connect was one of the first major purchases I made during my graduate school career. Yeah, that was one of these sort of off-the-shelf solutions that addressed some of those perception problems very nicely. So when we were looking at how to model and track human behavior, we wanted to be able to detect where the person was. So initially we had done things like put tags on people's hands, like a special hat on their head, but when we got the Connect, it just kind of worked off the shelf. So I think most of the nice tools and things that I've used have been similar things to the Connect. So the Intel RealSense is a really nice camera. It's very cheap. It's RGBD in depth. They also have a tracking camera that basically does slam and localization on board. So you don't have to worry about figuring out where you are in space. So it makes a lot of that really easy. In general, I think one of the things that has been really good in robotics recently is there are so many platforms now that aren't too expensive. So it's really nice to have just things that you can just buy and work in. Let's say you work on the algorithms or the other things that come into play. So in general, I think these off-the-shelf robots are really nice.

Q1: Describe the overall influence these tools have on your research?

Katherine Driggs-Campbell: These tools basically, on some level, they just give you more time. So when you're working on decision-making and planning and these kind of things that are, they're kind of, if you think about the robot stack, they're kind of at the end. So as I mentioned, if you want to be able to get to those questions and really solve them in a way that isn't just in simulation or in theory, if you really want to do a deployment in some real-world test, you do have to build up all that. So everything that you have to build up, that is so many hours of a graduate student's time and effort that they have to do. And a lot of these things, because you're trying to show that thing at the end, you're probably not going to do anything super innovative on these things that will allow you to ask those questions. So I think it's really, by having these off-the-shelf solutions where you don't have to worry about these things, it just allows you to ask these questions quicker. So I think it's really about expediting research and sort of being able to get to that point. And I think broadly, this is sort of supported by the recent push in robotics where it's become a lot more algorithmic, but we can still have the real-world things. And it's sort of because we have all this infrastructure and all these cool platforms and things that we can use. So you can ask the questions of the end game, oh, not end game, end of the stack. And you don't have to worry so much about these things sort of on the way.

Q1: Who finds your research and how have you developed those relationships?

Katherine Driggs-Campbell: So my work is funded by NSF. So I'm recipient of the NSF Career Award. So that's supporting our work in crowd navigation. Another project we have with NSF is on modeling how robots influence humans. So thinking about this sort of interplay when you have interactions that happen over time. So how does that change and adapt? For NSF, I think, I don't think you have to do too much to foster those relationships. I think you just need to write a good proposal. So I think it's kind of a more self-explanatory there. I'm also funded by the USDA. So this is both through the National Robotics Initiative 2.0 and also through an AI Institute. So we have an AI Institute on campus called AI Farms, which is funded through USDA. And to foster the relationships with USDA, I think a lot of it, I guess in some sense it's a similar review process to NSF. But for USDA, you really need to have some good grounding connections to agriculture. So you show that you're really solving some high-impact in real-world problems. So that's something that's been really nice about being at Illinois because it has such a deep relationship with agriculture and such a great ag (agriculture) department. So fostering those relationships was mostly about building the connections on campus and then circling it back to that.

Let's see. I've also, I've been sponsored by a few industry partners. So I've been sponsored by State Farm, which was a nice connection. They're also located here in Illinois. So there, they're really interested in how we can model human behavior and have that inform their decision-making. So that was one industry partner. Another one, we worked with Foxconn Interconnect Technology, which is a major manufacturing company. So they're really interested in seeing how we can sort of enable future manufacturing systems. So how can we move from the sort of current practices where you have, you know, you're scaling everything for mass production to being able to be a little bit more flexible and customizable. So we worked through there. We got very lucky in that the CEO is a alum from UIUC. Just built a nice shiny new building down the way. So we were able to connect through them. Over the years, partially through my PhD and postdoc, I was primarily working with autonomous vehicle companies. So we worked with a variety of different folks there. So Toyota, TRI, Toyota Research Institute. Ford has some projects there, SAAC, which is a Chinese company, Hyundai funded us initially. So I've worked with a lot of different automotive companies as well.

Q1: Does funding affect your research and, if so, in what ways?

Katherine Driggs-Campbell: I got really kind of lucky that when I started, there was, and it still is a big push in robotics. So I started my position in 2019. So I think there were just a lot of opportunities to grow out there. So I think on some level, because there was funding in a lot of different places, I was allowed or enabled to try a bunch of different things and kind of see what worked out there. I think one thing, so when I was starting my faculty position here, one thing I was very maybe concerned with was, so prior to joining here, I was in California. Most of my work was on autonomous vehicles. Most of my work was funded by industry sponsors. And I was concerned that I was putting too many eggs in one basket, so to speak. So it seemed like a lot of the problems, well, even though I think there still are some open problems and challenges that academia can contribute to in autonomous vehicles, a lot of it is becoming more of an

industry problem. It's kind of about getting that last little bit to really making sure that it's prevalent and out there.

So I was very, so as I was starting my position, one of the things I really wanted to do was expand into other application domains. So you can still do the same sort of fundamental work, look at how we can enable robots to do cooler things. and hopefully have them interact with people. But again, I wanted to see different ways we can apply it and different things there. I got very lucky being here at Illinois because we have experts in all these different areas that were able to kind of act as shepherds in some sense to these new areas. So that allowed me to make connections to the agricultural field that, I knew nothing about before coming here. It allowed me to learn about what are the big challenges in manufacturing? What is the sort of current state of the art? How can we take the things that I've been developing and translate them to that area? So again, I kind of, I got lucky in both that there were folks who could help me get familiar with these different areas, but also that the funding was there for it.

Q1: Is there any project you would have liked to pursue but haven't yet?

Katherine Driggs-Campbell: When I first started working on autonomous vehicle problems, initially a lot of the sort of push in advertising or about why they should exist and how great they would be was actually about things like improving mobility and whatnot. So way back when like Google had this cool demo where they took a person with visual impairments, they put them in the car and had them driven around. It was sort of an ad campaign that they had. And it was one of these sort of like cool, cool things. And there were a number of interactions that I had where I really saw how autonomous vehicles could be impactful with in general people there. But as I worked on this and as my PhD trudged on and then time passed and there's still no autonomous vehicles, it kind of seemed like if you wanted to design something that was really going to help people and really make a big impact on people's lives, it wasn't clear to me if that was the one. Like the biggest sell nowadays is like, it'll save you commute time, which is still really important, but it kind of lost this kind of feel good, good piece there.

So I was actually asked when I was interviewing for faculty positions, what area I would work on if it wasn't the areas that I had been. And I thought about it for a minute and my answer was some sort of assistive robotics. Because I think that's where you can have a lot of impact and really change people's lives. And you're not just giving them a cool new toy there. And it wasn't something I had worked on for a long time. I just didn't quite have the insider information. But yeah, just recently we started a project in assistive navigation. So I have a great collaborator in, let's see, the department is the Kinesiology and Community Health. So she's a psychologist, she's an expert in human factors and she understands and is an expert in technologies for people aging with disabilities. So it kind of just happened to work out. So now we're starting some new projects in this area. So it's again, not quite an answer to your question, but yeah, it's one of these areas that I've been really excited to get into and finally did.

Q1: What do you see as your most important contribution to robotics?

Katherine Driggs-Campbell: This is a tough question because I think this is kind of one of those things that like time will tell. And I haven't had a ton of time. But like I said, I'm excited about this assistive robotics project. I think it's something where we have some really good connections. I think there's actually some good opportunities to actually do some good translation. I've been very fortunate that a lot of my work that was or has been sponsored by industry partners has had some translation. So a lot of my early work in autonomous vehicles was transferred to our industry partners. Our recent work on collaborative manufacturing, we have some systems that are in the process of being deployed on factory floors. So I think I've been very, very lucky in that regard. More broadly speaking, I think a lot of the broader contributions of my research has been on how we can do better planning and decision-making while taking into account some model of the humans. So I think broadly my work and effort in that area has been what's been sort of picked up by the most people.

Q1: How has robotics changed and what future do you see?

Katherine Driggs-Campbell: Whenever I think about this sort of question - so my PhD advisor is Ruzhna Bheichi, who some people refer to as the grandmother of robotics. And she would tell this story about how when she was starting her faculty position, they had their robot system, which they had to build. And then she was trying to do some perception stuff. And she was a perception person. So that was, you know, in theory her jam. But they had to take, so they had a camera and then they had to build their own analog to digital converter for the camera because there weren't any digital cameras. So they had to build that piece just so they could start doing their robotics work. So every time I think about where robotics has been and where it's going, I think of like having to build this A to D converter, just so you can get your robot to work. And of course, this is like this huge system. And now we can, you know, we all have phones. You can just buy whatever there. So I think the, I mean, in my view, I think the biggest changes in robotics, again, with limited, you know, historical perspective, are the fact that we do have so many things that are open source and available. So even like making Ross publicly available has been huge. And it's something that's super useful for making things reproducible, sort of resolving a lot of the software hardware interfacing and all that. So I think that has been a huge game changer.

And then there's also, I think in general, just the cheap platforms has really changed the focus of things. So I think before, like if you look at older courses on like introduction to robotics, it's like about like modeling kinematic chains and things like that. That's sort of this old school view of what intro to robotics should be. It should be like about modeling kinematics. But now if you look at “newer” intro to robotics classes, it's like, okay, now you build the whole system. You have like a little car and you want to do racing or something like that. And you kind of go through the whole stack. So I think there's been a shift in what the major challenges are and sort of where you can focus your energy out there. So I think it sort of broadened the field a lot. So there's, I guess, where is that?

I do think where it's going, I think we're at close to a turning point where I think we are very close to seeing a lot more deployments and actual sort of getting robots into homes beyond just room buzz or maybe not homes, but into the public. I think we're getting pretty close to that point. I think a lot of the technologies have matured enough that again, I think there's a lot of opportunities to actually get robots places. I think one of the consequences of that will be a lot more emphasis on like robustness and resilience. So not so much about being able to do a cool thing, but being reliable in doing it. So with that, I think there's a lot of open questions and just safety and analysis and validation and whatnot there. I think there's also some other interesting questions that will arise and how do you make it easier to use? So for example, if you have some robot, how do you know it's going to work in other people's homes? Do you have any expectations of what that person can and should do with their robot? Can they guide it or provide it with some feedback to adapt it? Can you give them some insights so maybe they can help debug or fix it? Whatnot there? So I think there's lots of opportunities in that direction.

Q1: Do you think generative AI has made an impact on robotics?

Katherine Driggs-Campbell: It almost certainly will make a big impact. I don't know if the current things that have been, the work that has been done has made a huge impact. I think we're still trying to figure out what the new, the big change will be, but I view it as a very similar wave or trend to the deep learning boom. So when that came out, there was a lot of interest. People were trying to figure out where and how it would fit in. And once people figured it out, we've been able to really think about how that fits into robotics. And I think in general, like neural networks are now very useful in robotics and have proven to be very reliable there. I think we're in kind of a similar stage with a generative AI, where I think there's lots of different things we can do. We're kind of just playing with it to see what will work. And I think in a few years' time, it'll become very clear where it's useful and how we can use it.

I think one of the biggest things that we kind of need to think about is the generative AI stuff, it's text to text type reasoning. So all of the work that we've been doing, applying it to robotics is saying, okay, how can we take robotic stuff, turn it into text, use generative AI to turn it back to text, and maybe with some images in there occasionally. But I'd like to think that there is a parallel or a way we can start reasoning a little bit more about the types of robot sensor modalities and input-outputs that will make it a little bit more directly useful. So less like we're just trying to pull and see what works and what doesn't, and more that we can treat it as its own sort of robot solution there. The challenge is we can have the whole internet worth of text data, but it's hard to get physical, real world robot data for all the things that can happen. But I think it'll come around.

Q1: Describe your experience with your research in real-world applications?

Katherine Driggs-Campbell: I think a lot of my work that has been translated, it's been fairly straightforward. I think one thing that did surprise me was some of our work in collaborative

manufacturing. So we were really interested in how we can model human motion and how we can have the robot react to it. And we translated all that fine. But the thing that they were most excited about was kind of like the simple safety system we developed, which was like our baseline approach. And so we're like, okay, here's the baseline. And then our cool research is going to outperform it, but it turns out like the simple baseline was like what they were most excited about. So that's like what's being pushed out, which is cool, but not quite what I maybe would have hoped. (laughs)

Q1: What advice would you give students interested in robotics?

Katherine Driggs-Campbell: One thing I always tell students, which is the same thing my advisor always told me, was to just keep pushing. I think especially in robotics, it's very easy to get either caught up in the weeds or in some minor detail or really get stuck when something doesn't work. But I think being able to sort of push through things and play around, I think is really important for robotics. I think a lot of it is, it's about playing around and having fun. So I think being able to sort of quickly iterate and do all that is super helpful in developing robots.

Q1: Anything else you'd like to add?

Katherine Driggs-Campbell: I briefly mentioned my advisor. So just maybe a quick shout out to her. I think having mentors, especially in a really big field like robotics is super important. So I'm super lucky I had such an amazing advisor. So Ruzhin Avaichi, so she's like a big deal. Actually, one of the reasons I chose to join her group was an IEEE histories interview on her. She's lived like this really amazing life, and she was just so inspirational that I'm like, okay, that's who I wanna work with. But I think I've been very lucky to have a lot of great mentors. Nancy Motto is another one of them. That I think really, again, really helps in a big field like robotics.