Transcript

Speaker 1: You're tuned in to 90.7 FM, k a l x Berkeley. My name is Tesla Munson and this is the graduates, the interview talk show where we speak with UC Berkeley graduate students about their work here on campus and around the world. Today I'm joined by Phd candidate Christie Sheehy and the Vision Sciences graduate group here at Berkeley. That's right, right. Yup. You got it. Okay, perfect. So, uh, what, what is this group, this vision sciences graduate group?

Speaker 2: So the vision science group is a really diverse group [00:00:30] of people. So we come from psychology, biology, neuroscience, engineering and optometry. And all of us have the same thing in mind that we want to study the eye and how it works. And so my particular department is more optic space and I do engineering. Okay. And so you're through the optometry department then? Yup. So we're a separate group, but we're oriented in the graduate school of optometry.

Speaker 1: And what is it about the I have you just always been fascinated by eyes?

Speaker 2: Yeah, [00:01:00] they're just cool. Ever since I was a kid, I thought maybe I want it to be an eye doctor or an optometrist. But when I started learning more about engineering, I decided that I wanted to build systems that could, could look at the eye.

Speaker 1: No, that's great. And uh, is that what you did as an undergraduate?

Speaker 2: So as an Undergrad I studied optics, which was a engineering discipline at the University of Rochester in New York. And it didn't necessarily have to do with the, I, you can do optics for lasers or detectors, [00:01:30] anything like that. So I found that I enjoyed doing the I when I did an internship one summer there.

Speaker 1: But did they make you play with lasers first and yeah, call scopes and you're just, okay. Well I want to hear, I want to hear a little bit more about that, uh, program. So what does that entail exactly? Is, is, is it just a room filled with telescopes and lasers and you just 0.1 at the other one or

Speaker 2: that would be awesome, but it's not quite like that. So the program is a four year program and basically it's a mix of physics [00:02:00] and science, physics and math. And what we do is we study the way light propagates. So there's like three different ways that you can think about light. You can think about it as a way and you can think about it as a wave and then you can think about it as a particle. So all for a year as you're kind of studying just how light propagates through air, through different media, different detectors that you can use to detect the light, ways that you can build lasers. And then it eventually goes right [00:02:30] back around to a course that I took on vision and the eye because the eye has its own optics inside. And so that's how the link is there. Did you have a particular project that you worked on while you were there?

Speaker 2: When I was an Undergrad, I worked in the lab of David Williams and he was one of the first people who decided to use adaptive optics technology for the I. So originally this technology was used to correct for atmospheric turbulence when people had telescopes and different astronomy tools and he to it would be a good idea [00:03:00] to correct for the optical media in your own eyes so that you could image the back of the eye, which we call the retina and understand how different light sensitive cells worked. And so I got to work with him and that was really awesome.

Speaker 1: So why couldn't we already do that? Is it, I mean is it because you just can't see through the eye or is there some other reason?

Speaker 2: So for a lot of us, we have what we call lower order aberrations. So maybe we have defocus where we're nearsighted or farsighted or [00:03:30] we have a stigmatism where we see slightly distorted images. But there are also other higher order aberrations that can cause distortions of light. And so if you try to look at a light, sometimes at night you might notice that that perfect spot of light, like a far away streetlamp, it doesn't look like a perfect circle. And so that's kind of a way that you can think about how your eye is somewhat distorted. And so in order to go through the optics of the eye to the back, you have to correct for it.

Speaker 1: So your example involves looking out of the eye. Can you look into [00:04:00] the eye as easily as you can look out?

Speaker 2: So for the technology that we use, our lab does use adaptive optics technology. And so what that does is a laser shines into your eye, it illuminates your eye, it's totally safe. We have light safe levels and the light then reflects off the back of your eye and comes out distorted. And that varies for every person. Every person has their own set of unique aberrations in their eye. And so this distorted wavefront is sent to a detector [00:04:30] that's a tech's exactly how it's distorted. So instead of being a perfect line, it's kind of a squiggly line or some sort of distorted line. And then when you have this sense, you can send a signal to a mirror, which can then correct and compensate for your eyes aberrations. And then when you have this loop, you're able to correct for your own eyes, aberrations and see perfectly to the backed individual single cells, which was really cool.

Speaker 1: Okay. So I can definitely see, you know, some of the physics [00:05:00] and math in there. But you mentioned you're also interested in engineering, right? How does engineering play into this idea?

Speaker 2: So these systems aren't really commercially available right now. There are a lot of custom built systems. And so my advisor, Austin Roorda, he was, he has a patent on the adaptive optics scanning laser ophthalmoscope, which is basically a fancy way of saying he has a system that can correct for the eyes aberration in real time through movies. So he collects a bunch of frames of the back of your eye and then you're [00:05:30] able to see different, different people's retina as those that have diseases, those who don't. And so that just got me really interested in thinking how I could apply my engineering to help look at retinal diseases or look at retinal conditions. And so that's when I decided that I wanted to do eye tracking for my project.

Speaker 1: Okay. And before we get too much into your current project, um, I know you had a transition period between your undergraduate and now and actually went into industry. Can you tell us a little bit [00:06:00] about what that was like?

Speaker 2: Sure. Um, after Undergrad I applied to different industry positions, so I wanted to stay in New York state and I applied to Corning, which is a company that makes glass and they had a special branch, uh, just outside of Rochester and they were hiring entry level engineers for their laser optics division. And I applied and they hired me. And so I started working there in June of 2007, just a month after graduating [00:06:30] undergrad. And I was really excited because you always hear about industry being lots of money and I can start to pay off my student loans. And it was exciting at first. And, but then I realized it was a lot of older men that were like 50 years old. I was in a clean room. I didn't get to really interact with a lot of people except for the glass. I really only got to interact with the glass that I was testing. And so I decided that probably wasn't the most ideal place for me because I enjoy [00:07:00] talking to people, running ideas by people and that sort of thing. So when they downsized my company about two years later, I got another, a second chance of figuring out what it was exactly that I wanted to.

Speaker 1: That's funny that you mentioned it was just like old white men because sometimes we make jokes about academia and the sciences also being just old white men. But clearly that's not the case because here we are talking about, um, so you were in a clean room. It, what does that entail? That's like full body suit coverage,

Speaker 2: [00:07:30] molecular level clean rooms. So I didn't have to wear like an astronaut suit or something, but I did have to wear a hairnet. Gloves. I could coat booties over my shoes. And they, they discouraged you from wearing makeup sometimes because if you had like powder foundation that can fall on the optics. And so that wasn't as funny there.

Speaker 1: Yeah, no, I, I could see that being a little, uh, sterile, so to speak to pun definitely intended. So if you're just tuning in, you're tuned [00:08:00] in to the graduates here on KLX 90.7 FM in Berkeley, California. My name is Tesla Munson and today I'm speaking with Phd candidate Kristi Sheehy in the division scientist graduate group here at Berkeley. She's been telling us about some of her earlier work with adaptive optics and industry. And so you said now you're really into eye tracking. Yes. So what, can you tell us what that is? That's just watching which way the eye goes. Yeah.

Speaker 2: Um, so there are a lot of different ways to do [00:08:30] eye tracking actually and a lot of people have seen the video based eye trackers where they put it over your head and it's kind of this cumbersome thing that you actually wear. And those can sometimes monitor your pupil or the corneal reflection. So the reflection off the top surface of your eye. But the one that we're, that I'm working on in my lab is a image based eye tracker that tracks the retina. And so it's actually tracking the very inner most layer of our eye. Okay. Keep going. What, like how do [00:09:00] you, how do you do this? So the technology I designed is um, basically an instrument that is used to relay the pupil of our eye onto a camera. And how it does this is it takes light from a laser diode and it Kolomiets the light, which means it sends it out.

Speaker 2: All the rays of light that leave the system are, um, are parallel. And so this parallel light then enters into a series of three telescopes. And when you think of telescopes, you don't have to think of the ones that are only for space. [00:09:30] A telescope is basically two mirrors or two lenses that are used to realize something. And so we use three sets of telescopes and the first set of telescopes goes to a horizontal scanner. So it's gonna scan your eye horizontally. The second telescope goes through a vertical scanner that's gonna Image your eye vertically. And then the last telescope is used to relay this onto your actual human eye or the subject that's sitting in the system. And then when the eyes reflected off the back of the retina, it'll pass back through the system [00:10:00] to a camera that will detect the intensity. Basically that's hitting this camera chip.

Speaker 2: So you're sending light into the person's eye and then you're tracking basically how it's reflected back out in the eye, right? So we get an image that makes up a specific field of view that we're looking at. So in general, the system that I made can be anywhere from one or two degrees up to 15 degrees, depending on how you wanna specifically design your optics. And so what we do [00:10:30] then is we have this square or this imaging raster that's immature retina. And if you break that up into individual strips, so you take one frame and you break it up multiple times. Each one of those strips has a record of where the eye has moved in time because it's constantly scanning your eye as, as you're recording a movie. And so each one of those strips has both the x and y displacement of how the eyes moved.

Speaker 2: So in order to just track the eye in real time during [00:11:00] imaging, you're able to get both motion and structure at the same time. Motion and structure. Adam, I'm not sure I follow that phrase. So motion would be how the eye is moving. So if I have a reference frame and then I have multiple frames following after this reference frame, if I want to match each of the corresponding frames with the first one, there's going to be some x and y motion over time. And so I'm able to keep track of how the eye has moved since the beginning because that reference [00:11:30] frame is my first initial frame and then the, I had done something throughout the course of the movie and structure just means I'm taking a picture of the eye. So I'm just looking at the retina. I can see the retinal structure, I can see the cells, I can see blood vessels and blood moving throughout the eye.

Speaker 2: And so I'm able to both look at the eye and see where the eyes moving at the same time. And how much does the eye move? You said it just moving constantly. It's constantly moving. So even when we're just fixating on a spot, our eye is always moving. [00:12:00] And so there are three types of motion that happened during fixation. We have draft, which is like a very slow drift to the eye. We have [inaudible] cards, which are fast jerk, like motions, and they're usually trying to bring us back to the center of gaze. And then we have very high frequency noise that's called tremor. And it's about 90 hertz. Frequency is is one over one over time. So your tremor is very high frequency and usually it's super imposed upon this slow drift. And so even when you think you're just looking at something, [00:12:30] you're always moving.

Speaker 2: Do we know what the purpose of this is or what the function of the Cy Movement is? Yep. So if I were to have a completely stable eye, the image of the world would fade. So there have been tests that have been done that within 80 milliseconds of time when you stabilize an image onto your retina, the image fades. And so our Chi, our eyes are constantly in motion so that we can see the outer world without it fading. And you'll notice this because our eyes have lots of blood vessels in them, [00:13:00] but we don't see them every day lights going through our eye and we don't see blood vessels covering the entire world. And that's because they're completely stabilized. They're completely stationary on our eye. And so as our eye moves, they move with it completely stationary and we don't see them. So basically we're, we're almost programmed to ignore things that are stable.

Speaker 2: Exactly. And so we have to keep moving our eyes so that we don't just forget the world is there. Yeah. Interesting. [00:13:30] That's really interesting stuff. So, so people volunteer for this? Yep. We have different subjects come in. We do normal imaging. So students, usually people in our lab who volunteer for each other and we just want to get normalized data. How the normalize moving. And then once you have that, you're able to compare to different retinal diseases. So if I have macular degeneration, if I have glaucoma, if I have other diabetic disease that can affect the eye, how does that change [00:14:00] the way my eye moves? And can you tell us about some of those differences? So I actually haven't looked yet in my particular machine at a patient. That's the last experiment that I have for this year. And so starting in December I will be looking at different patients with macular degeneration.

Speaker 2: But in general, patients tend to have more instability than normal subjects, particularly with macular degeneration. So you would expect to see like more jerky movements or just more movements in a patient? [00:14:30] Yeah. So with macular degeneration, usually you use what we call your phobia for fixation. So it's the highest density of light detecting cells in our eye and it's very tightly packed with these cells. And that's the area of the eye that we would use to watch TV, read a book, do very high acuity tasks. But that area falls our macula or the center of our vision. And patients that have macular degeneration have basically a deterioration of this region. And so suddenly [00:15:00] they're no longer able to use the same place for fixation than a normal person would. And so they're forced to go out somewhere in the periphery or somewhere else in the nasal or superior region anywhere else. And that can affect how stable that their eye is.

Speaker 1: So obviously you do a lot of this work in your lab here on campus, but as I just now learned, you have done some research training abroad as well.

Speaker 2: Yes. So we had a postdoctoral s uh, [00:15:30] student in our lab, his name is Wolfe harmony and he was from Germany and he came to Berkeley for two years, post his phd to do some work with Austin Marta. And he went back to his home country of Germany and he started to build his own lab there. And he asked my advisor if there's anyone in the lab that would be willing to come and start to build his systems for eye tracking and imaging. And I said, count me in. I'm totally going to do it. And so we worked out a research [00:16:00] exchange where I was in Germany from May 28th through September 17th I believe, and I worked in his lab and an eye hospital there and I got to build an entire system on my own there and I had free weekends, got to travel. So it was a really awesome experience overall

Speaker 1: that, that sounds really awesome. Had you been to Germany before?

Speaker 2: I had never been to Germany. I can't speak German, but the lab that I worked in spoke English and all the colleagues on the same floor spoke English. [00:16:30] So in in the science world it was definitely okay. Yeah,

Speaker 1: of course. And so when you say you had to build your system, what does that entail?

Speaker 2: So I had to build for him an adaptive optic system, which I explained earlier and I had to build for him the eye tracking system, which I also talked about earlier. And when you combine the two you can have active eye tracking for the eye. So this [inaudible] system does high resolution imaging and the eye tracker does eye tracking. So if you combine that, you can have a high resolution [00:17:00] imaging system with tracking capabilities. And so basically doing the engineering for that means that I had to use an obstacle design software to design where the optics were going to go and what was the optimal performance. Then I had to order all the parts and make a parts list, like an excel and pick out which parts would be the best for the actual building of the system. And then when I got there, I got to put all the parts together based on the optical design. And then finally you put a laser [00:17:30] in the system and you align everything so you make sure that the light is going where you want it to go.

Speaker 1: And so they're also gonna use this system for medical research?

Speaker 2: Yes. Um, that's one of the aspects of their grant. They're also going to do it for basic science though. And so they're doing a lot of single cone psychophysics. We're, they shine a light into your eye and they want to see what you perceive, what color you perceive, what threshold of light you need. So they're doing a lot of very [00:18:00] precise single cone stimulation.

Speaker 1: So psychophysics that seems like a very specific word. Can you tell me what that means?

Speaker 2: Sure. It's basically science through the perception of a subject. So if I shine a light into your eye, there's an objective way of looking at how that light reflects back. But there's also the opportunity for me to ask you what you see and what your brain is processing. [00:18:30] So if I shine a light in your eye and say, what color do you see? You have the capability to respond and say that looks green, that looks white, things like that. And so psychophysics is a way for scientists to ask questions through the perceptual experience of another person.

Speaker 1: Interesting. So I, I, I at least was always one of those kids who wondered, you know, when I look at the sky like, you know, and I see it's blue. What, what does someone else see when they look at it? Is there variation of people answer differently?

Speaker 2: [00:19:00] I mean, there are people that have certain colorblindness, there are people that have different perceptions of the color of blue. So someone that sees the sky as a certain shade of blue, there is a possibility that they could see it somewhat differently from how you perceive it. Definitely. But probably we're pretty much on the same page. It's not like pretty much. Yeah. But there is the chance for someone to see it differently than you. And so do they get to

Speaker 1: keep all that machinery or since you built it, the, it doesn't stay under your name.

Speaker 2: They get to keep all the machinery. [00:19:30] So it's machinery that I designed through Berkeley and since it was a research exchange with Berkeley, it's kind of the universities and there's to, to handle, it's not necessarily mine as an individuals.

Speaker 1: And you mentioned that your group, your graduate group has students from all sorts of disciplines. Do you work with a lot of those other students or is it everyone you work with mostly coming from optometry?

Speaker 2: So we have a really broad, um, a broad laboratory. So the person [00:20:00] that runs the lab, his background is in physics. We have an ophthalmologist that works in there who's a clinical researcher. And so he brings a lot of medical background to the experience. We have um, two optometry students that had gotten their o d degree and then went back for their phd. We have one biomedical engineer, we have one computer software engineer, and we have another student who studied optics as well. [00:20:30]

So this definitely a broad base in our lab. And the program as a whole is even is even more broad.

Speaker 1: Can you speak really quickly to the benefits of having such an interdisciplinary group?

Speaker 2: I think it's fantastic because I don't have a very strong background in biology, for example. And so when I'm building a system, I may know the optical tolerances of my system, but I may not know exactly how something will work once it actually goes into the eye. And so if you have someone there who's done optometry, who's done ophthalmology, [00:21:00] who's done other biomedical imaging, they're able to have feedback for you. And so any areas that you're lacking, you can make up usually in your laboratory if it's very diverse.

Speaker 1: And are your interest mostly medical and medically focused?

Speaker 2: For now, I think yes. When I first did the industry job, I, I looked just at glass and damaged thresholds and lasers and I really wanted there to be an application that I would feel more fulfilled with. I feel like with the medical [00:21:30] aspect, everyone has a much easier way to relate. There's always someone that, you know, that has some sort of eye problems even if it's as little as glasses. And so I wanted to actually be able to help people and not just help machines.

Speaker 1: No, I mean that's, that's obviously a very noble cause. Um, so you see yourself staying in in medicine, at least medical applications for your engineering projects for now, yeah, I think so. There are there, there must be other applications though as well, even if they're not as [00:22:00] interesting to you.

Speaker 2: So I mean eye tracking in general as just a broad topic can be used in multiple ways. People do eye tracking for Google for example. So if you want to look at a website, what areas attract you more than others? You can do it for ads. You can do it for security purposes. So people do a lot of scanning of your eye first, you know, really high security stuff like that. So there's lots of different applications that you can use eye tracking for. I just happened to find the medical [00:22:30] ones the most exciting.

Speaker 1: There's nothing wrong with that, that's for sure. Uh, so you're working more on the basic science and the discovery side side of things now trying to understand how patients differ from a normalize and how you can mediate that. But do you think it will ever circle back around where you can apply your technologies to like directly improve someone's life? Or is this basic science, which is obviously the most important science? I mean, is this a terrible question? [00:23:00] No, no.

Speaker 2: It's basically why are you doing this? And I think that's really important for every student to to answer. I guess the answer would be in that I would love for this technology to become sort of an early diagnostic screening tool. So if we do research and we find out that, you know, macular degeneration has a specific fixation, Anil issue with it early on in the disease, there could be a way where you could sit in this machine, just fix [00:23:30] it on a spot for a period of time. And you would say, okay, this patient is fixating somewhat irregularly. Does it look like what we've researched in the past for macular degeneration or even neurological disorders can have fixation instability. And so there's a lot of different diseases and pathologies that you can look at and be able to say, is this normal or is this not? And if you could early screen for early detection, that's the best you could have [00:24:00] if you're able to intervene on a disease very early and try to stop, prevent it.

Speaker 1: And what's the earliest that you think you could do this? Do you have any sense of how these eye movements change as an individual gets older?

Speaker 2: So as an individual gets older in general, the optics of the eye will change for sure. So you might know people that have had cataracts as they age, where their lens kind of gets foggy. You might notice that they become presbyopic or they're suddenly not able to read a book up close without their that their bifocals. [00:24:30] There isn't, hasn't been much to say recently about specific fixation changes just with age. That would be something interesting to look at though. Normally you either classify it as a normal individual, meaning you don't have any retinal or neurological condition or you do. So there hasn't really, I don't think have been a study looking at how I'm movements change over time.

Speaker 1: Well the things to think about I guess. Yeah. A what if, so what if someone was interested in that question or you know, a student is interested [00:25:00] in optic sciences, what would you recommend for them in terms of getting involved in research?

Speaker 2: So I think for a student who's extremely interested in a topic you, you're always welcome to email a professor, see if you can get a tour of the lab, email a graduate student in the lab to see if there's any availability to come in. And just check it out. Most departments have talk sessions, so maybe once a week, every Monday for example, in our department you can go to a talk on a specific [00:25:30] area of that department so you can go listen to people talk about optics or biology or neuroscience or whatever you're interested in and see once you've gone to a bunch of talks is this kind of the area that most excites me. And so I encourage people to go to those talk sessions to talk to other people there. Because if you're in person sitting next to a professor and you introduce yourself, it's much more likely that you're able to show your excitement to someone in person than through an email.

Speaker 1: No, that's a great advice. And uh, [00:26:00] speaking of excitement, do you think you'll ever go back to industry or is that a way of the of the past?

Speaker 2: I may go back someday. It's going to be much different now that I have a phd than when I was an entry level engineer. I think once you have more education and experience, you're able to do more of the decision making than just the building just being told what to do. So I'd be more excited to go back and be able to be the thinker of what they could try next.

Speaker 1: Okay. And you, you mentioned to me briefly that [00:26:30] you actually have a life outside of Grad school, which is rare. So you want to tell us about that briefly. What, what is this life? What is this thing called life?

Speaker 2: Yeah, so as a Grad student, at least in my experience, you can have a life. So I think a lot of people assume if you're a graduate student that you're in lab late at night, you kind of live in a cave, you don't see the outside world, you don't know how to interact with them. But I've definitely tried to have a lot of a work life balance. And so [00:27:00] in general I might work nine to six 10 to six during the week. If I have work to do, I'll bring my laptop home. I won't stay in the lab for longer hours. I, my first year I joined a salsa dancing team in San Francisco and so I did that and we did, we performed. And that was really fun. I've definitely used a lot of the cal adventure activities that they have here. So I've taken when surfing and paddle boarding and kayaking. And so I just, I really enjoy taking advantage of [00:27:30] the bay area and the things that you have around here to do. And I encourage everyone that's a grad student or an Undergrad that doesn't take time for themselves to really do it because if you want to work really hard, you need to have a break sometimes. Otherwise

Speaker 1: just go crazy. No, I, yeah, I appreciate that sentiment. Um, I look forward to doing that in my own life, but a no great words of advice. Do you have any last words as we sort of wrap up here? Any other words of advice for the audience? [00:28:00] I mean, those were pretty epic, but if you have more,

Speaker 2: well, I, I guess my last thing to say would be that things aren't always what you see. Everyone sees the world quite differently based on their optical aberrations. And when you look into different people's eyes and you classify the different structures in their eyes, you'll notice just how even if small changes, you'll notice that the slight changes between you and your friends can affect the way that you all see the

Speaker 1: world's. So cool little tidbit. [00:28:30] Yeah, I know it's, that's really interesting cause we all think about it, you know, subjectively, uh, who we are as a person. We see the world differently but also quite physically and biologically we see the world differently as well. And uh, you're there to help us classify that. So thank you so much Christie. Thank you. And that's gonna wrap it up for this episode of the graduates here on KLX Berkeley. My name is Tesla Munson. Today I've been joined by Phd candidate Kristy Sheehy in the Vision Sciences Vision Science Graduate Group, [00:29:00] uh, here at UC Berkeley. She told us about her work in eye tracking and image stabilizing and research abroad in Germany and all sorts of things. And again, it's been a great pleasure having you here today. I didn't actually know there was a vision science group. So it's, most people don't. Some I'm psyched that I got to spread the word. No, absolutely. And remember, we all see the world differently, so thank you. We'll be back in two weeks with another episode of the graduates here on Calex [00:29:30] 9:00 AM on Tuesdays. Until then, stay tuned. You're listening to 90.7 FM k a l x Berkeley.