Sue Nelson

Hello, I'm Sue Nelson and thanks for joining me on Create the Future. A podcast brought to you by the Queen Elizabeth Prize for Engineering. Engineers are known for being creative problem solvers and like scientists often have a number of strings to their bows, but I have to admit to not coming across an engineer like this one before. California based, Justyna Zander is considered a bit of a technology Rockstar in autonomous cars, often cited as one of the most powerful women in engineering, she's an expert in artificial intelligence and machine learning, has worked at Intel, Harvard University, and the White House, speaks five languages, and if that wasn't enough, is also a licenced Zumba instructor. But her day job is Global Head of Verification and Validation | Simulation Architecture for Autonomous Driving at NVIDIA, one of the main companies building the underlying technologies for self-driving cars. Justyna thank you for joining me on Create the Future. You're living in America, speak fluent German, English, Polish, academic level Russian, and primary level Italian so I wanted to start with by knowing which one of those languages do you dream in?

Justyna Zander

It depends what I'm doing and where I am located. My dreams are changing depending on what is occupying my mind. Today I dreamt in English.

Sue Nelson

That's so interesting. You're originally from Poland though.

Justyna Zander

That is right.

Sue Nelson

But you went to you did a lot of your schooling in Germany. Why was that?

Justyna Zander

I was born in Poland and when I was 21, I left to Germany. And the reason I left was because I wanted to do something meaningful, impact the world in a meaningful way. And in Poland I was a student whereas in Germany, when you are a student you are actually allowed and welcome to work for research institutes. I immediately took on a job in a research institute called Fraunhofer Institute for Telecommunications, at the time, it was in Berlin, Germany.

Sue Nelson

And you've got two degrees. You've got one in computer science, one in electrical engineering. So was it at the Fraunhofer Institute that you studied electrical engineering?

Justyna Zander

So, the way the studies are structured in Germany is that you do computer science and electrical engineering at the same time. You couldn't just do computer science. Actually, altogether I have six degrees.

Sue Nelson

Six? Sorry, I'm just a bit gobsmacked by that!

Justyna Zander

Yeah, I was a little bit of education freak. You know, I did a lot of degrees in parallel. So first environmental protection, then computer science and electrical engineering, and then master level and PhD level in computer science and electrical engineering. And then also I did something like, kind of like mini MBA in technology. At

the time, it was at the Singularity University at NASA Ames in California. And it was about exponential technologies or exponentially growing technologies.

Sue Nelson
You must have a tremendous thirst for knowledge?

Justyna Zander
I just enjoy it. I derive pleasure from learning new things and advancing.

Sue Nelson
And when did that start as a child? A lot of engineers say they were always constantly taking things apart. You know, interested in how things work. Is that how you were as well as a child?

Justyna Zander
That's really interesting. I wasn't like this. I don't think it ever started. I just remember it just always was like this. I remember my grandfather asking me about school, and asking me how do you like school in the first year of school when I was six. And I thought, you know what, I'm gonna keep learning as long as I can. So, I guess I promised something that they still hold on to.

Sue Nelson
So, you're extremely academic, what is it about electrical engineering that really caught your attention? What did you like about it, that and the combination with computer science?

Justyna Zander
So there's a difference between doing things in abstraction, and building stuff. And when I encountered electrical engineering and mechanical engineering, to me, it was like, you can finally actually build stuff and you can make things. So that was a discovery to me. And it turned out that the way you make things when you combine them with the high-tech technology, so with computer science, you can actually advance them a lot. You can see it in, in cars, but not only you can see it in robotics. You can see it in healthcare, the way we advance. So, all of a sudden, you could combine multiple things and make them even better.

Sue Nelson
You've had a number of roles and positions before you joined NVIDIA, including doing start-ups and working at Intel as well. Which of your jobs do you think has a sort of taught you the most as an engineer?

Justyna Zander
It depends. Because once you go over your stages in your life, your brain is also, you know, is getting a new perspective. So, at every stage of your life, you're learning new things. And I wouldn't say that one was more advancing than the other.

Sue Nelson
So it's been a gradual stage, continual learning. Let's go back then to when you were a teaching fellow and you worked at NASA Ames at the Singularity University. What is the Singularity University?

Justyna Zander
It's a school that has been founded by pretty famous people like Peter Diamandis, Ray Kurzweil, who are living in American capitalism and making a lot of improvements to the world, advancing in order to impact humanity in a positive way. Singularity University actually does not exist in the form it used to exist anymore. They

changed the business model a little bit. Basically, the idea is to do something really, really good on the big scale.

Sue Nelson
And when did you first start becoming interested in the concept of driverless cars?

Justyna Zander
Maybe in Germany, when I was doing my PhD, I did it in collaboration with Daimler. At the time it was Daimler Chrysler. It was a very intellectually stimulating when you were thinking that actually the car could drive you and kind of like read your mind as opposed to you doing all these things that you have to repeat every single day.

Sue Nelson
And what aspect of the car in terms of your work were you most interested in?

Justyna Zander
It's coming in stages. So, you know at the beginning, I didn't know About the engine and how the mechanics work and what you can actually automate through software. So, all those stages, the way car industry was being transformed was very interesting. 25 years ago, we used to use a lot of controllers and software was built to control the controlling units. Nowadays, software is built differently, the automated driving or autonomous driving is built using neural networks. So, it's a different computer science paradigm than it used to be. So, the transition is always very interesting because all of a sudden, you don't have the controllers the way you used to have. You do your controlling slightly differently. You are using a lot of neural networks in order for the car to drive properly.

Sue Nelson
So take me through then in a very sort of simple way. A lot of our listeners are students who are interested in becoming engineers, what is a driverless car in terms of how does it work?

Justyna Zander
It's actually simpler than you would think. Basically, your car is like a robot. It's basically a robot that is performing a certain task for you. And now this robot has to sense the way humans sense. So, if you compare the driverless car to a human, it would be the sensors on the car that are perceiving the environment around itself. So, for example, for humans, the sensors are eyes and ears, whereas for the car, the sensors are cameras, radars, LIDARs, depending on the technology that is in use. So that's the first stage – you sense, and you perceive, and then the next stage is you how you're going to go. So, for example, for a human, I have to go from, from my living room to the kitchen. So, in the human mind, your brain is wired in this way that you know how to perform this task. For a car, you have to teach the car how to do that. So, the car has to have a route and has to plan for this route, and has to be able to control how to get there. The third stage is you actually have to act. So, you have to perform this action. So, as a human, you just get up and you go from your living room to the kitchen, you're using your legs, whereas the car has to act with the actuators that it has available in the car. So, these actuators are basically getting commands from it from your planning, kind of from your brain and performing certain set of activation steps in order to start the engine, drive through the route and stop. Does it make sense? Does it help you?

Sue Nelson
It does. It's a very complex set of stages, isn't it? And obviously you need a lot of data, I would have thought in order to end up with a system that everybody feels confident in.

Justyna Zander

That's right. And, you know, in artificial intelligence people say that this is the most complicated system humans have ever designed. In a sense, it is because of the AI that is being used. So, the way it works in that sense stage that I told you about, when the car has to perceive the environment around it, it's actually not about just sensing it's also about collecting the data from your environment in order to learn. Basically, the recording from the sensors is teaching your neural networks in the software of the car, how to behave and what decisions to make for you. So, for example, you drive through a stop sign and your car is seeing a stop sign a million times. Once the car saw the stop sign from the camera a million times. It's going to finally learn that the stop sign means that the car has to stop. That's basically how you train your neural network, you train it through the images that you're collecting from the road. And once you have a million of these images, at some point, the car is going to be able to do it by itself. This is why neural networks in the car are typically deep learning neural networks, meaning that you're learning from the images or from the surrounding recording of the surrounding that you take for your sensors.

Sue Nelson

So if someone was going on a specific route multiple times, the car would effectively get to know that route and what the specific things going on there and sort of almost predict when they're coming to a specific place.

Justyna Zander

That is correct. I'm glad you're bringing this up. Because one way to think about autonomous cars is to think exactly this. You go through just one route and you learn what is going on that one simple route, let's say, one mile from your workplace to your home. That's one way to do it. Another way to do it is you want to scale this effort up. And you want to teach your neural networks about everything in the world. So, you have to scale this up within your town, then within your state or country, depending where you live then within your continent. You know, the problem becomes even more complex when you want to make it a commercial solution that works for everyone everywhere.

Sue Nelson

And what would you say are the advantages of having a world with autonomous cars over what we have today?

Justyna Zander

The biggest advantage, you know, from the human perspective, like humanity perspective is safety and comfort. So basically, you don't have to worry about the effort of driving. The moment of autonomy is here, let's say in about 25 years or so, you just gonna roll into your car. And it's going to take you wherever you want to go. And you can focus on whatever occupies your mind at the moment or whatever entertainment you would like to be entertained with. And then you'll get this guarantee that it's going to be safe. So, all of a sudden, it does not depend on your mental state or thoughts or on your driving ability. It's just gonna happen as a safe thing that you take for granted. That's actually a very useful advantage for humanity.

Sue Nelson

I remember in the mid 1990s, making a radio programme for the BBC, on robotics, and going to MIT in the states and seeing a prototype for a self-driving car. And it felt at the time as if we were actually, you know, within 10 years, it could be happening. And like so many, you know, new technology's – disruptive technologies – it's been far longer than people would have expected. Why do you think it has taken so long to get to where we are now? And do you think we're at some sort of tipping point now where we're about to finally get there?

Justyna Zander

Yeah. So, there are very factual technological reasons for this. In the 90s, I can see how you saw a prototype actually, the first prototype was in the 70s. The reason it took so long is basically two things happened. One, we advance over computing capabilities, in particular parallel computing capabilities, and two because of this parallel computing, we can do neural networks much more efficiently than we used to do. So you now, all of a sudden have deep learning as a result of parallel computing. That's one. And then also, we became very much software defined. So, we learned as a humanity, how to build things that depend on software much more so than on the mechanical switch. And this is why now we're able to build things in a different way. And for autonomy, it means we can leverage deep learning. So, all you need is a proper set of sensors on your car, in order to make it drive autonomously. Now, the technology is there. Every start-up can build the autonomous car nowadays, everybody really – it's not that difficult to build a demonstration. However, it's extremely difficult to build a commercial product. And the reason it is so difficult to build a commercial product is that it's not about just demonstrating how the technology works. It's about making it safe. And in order to make it safe, you have to follow a set of safety standards and general development standards. So for this, you have to build a lot of engineering into your process, how you build the software, and then also verification and validation, all of a sudden becomes half of your engineering budget, because of basically the reliability that you have to build into your system. Whenever something bad happens, your system has to be able to react and save you from that.

Sue Nelson
I mean, I personally, I would love a self-driving car. I've always been intrigued by the concept I think ever since going to MIT and seeing their version. And also, I just think it makes sense as well like you say in terms of safety, and it will probably help with traffic management on the road as well. But a lot of people are very sceptical about it. Is there the same amount of scepticism in California which you know, by its nature, you know, it's the home of a lot of technology companies. Are people there a little bit more open to the concept>

Justyna Zander
I'm also a very sceptical person, because remember my background comes from Germany. And in Germany, it's all about the standards and how you do things – engineering process, step by step, not running but really going through every single step with seriousness. To me Silicon Valley, it was an adjustment of mindset. It took me a while to be honest, to accept that you can do things differently, and they may as well work. So that's on scepticism. Now I'm excited about self-driving cars. I'm also excited about driving the car especially if it is an electric car. It gives a lot of joy, you know, the acceleration and the way you can navigate your car. It's much more robust than the motor engine. So if I think about cars, I really think about electric cars being the biggest advantage for humanity and autonomic comes as a, you know a bonus. I like that autonomy because it can help us in certain situations. For example, if you think about pandemics now, as we're experiencing, it would be nice to have autonomy in delivery systems. So the car would basically pick up your groceries and come to you and bring them to you. You don't have to touch anything, you don't have to talk to anybody. So you're safe. But there is a lot of, you know, expansion from this autonomy thinking, I think that building something like an electric supersonic flight is what excites me even more. And the reason it excites me is because it's environmentally friendly, but it's also very, very fast. So imagine if I'm a person who, who is really very much related to three countries in the world. And if you ask me, what is my home country, it depends on my mindset what I would answer to you, so my objective answer is really it's Poland, Germany and the US. So, I want to travel between those countries very, very fast. Because I have loved ones in every of those countries and I want to see them. I want to see them very frequently, if possible. If you have supersonic flight, you get there very fast. I'm sceptical but I'm also a believer. I'm also an optimist. I think the human mind is conditioned to build things.

Sue Nelson

Yeah. So it just takes a bit longer for human minds sometimes to accept certain technologies because just people start with a bit of reluctance, I suppose. And yet people are now starting to use the automatic parking in function in certain cars. And that's just like one small step, isn't it?

Justyna Zander
That is correct. And, you know, the human mind is also you know, it continues to excite me how quickly humans change. You can see it especially in California, but in other countries When people start driving the Tesla, all this scepticism suddenly disappears. Because all of a sudden, it's actually so joyful not to have to drive on your highway. People learn this very quickly that when it feels safe, it actually is going to be safe. And sometimes people learn too quickly. So sometimes people give too much trust into technology. It's very important to educate people what you can what you cannot do with the current state of the technology. You know, I was thinking the other day about humanity and how we use cloud computing nowadays, imagine that the internet would be down for a couple of days, all of a sudden, there is so many things that you cannot do anymore. All of your financial obligations, probably taxes, but also, you know, entertainment accounts for gamers gaming for TV watchers, all the TV. It's all in the cloud. You don't exist without the cloud anymore today, social networks, it's in the cloud. So what I'm saying is that cloud computing is accelerating in dominating our life without us really being aware of that. And so if you think about the pandemic, now, you could think that we would want to build a something like a computational defence system that is going to defend us from, you know, the invisible enemy. But at the same time, you also want to give the computational system that is going to defend us from the cloud computing dependency that we developed as humans.

Sue Nelson
Great thought and very relevant as well, I think I mean, it's that sort of thinking, there has been sci-fi thinking for quite a long time as well in terms of a dependence on one technology can be a dangerous thing. You mentioned you know, some interesting ideas there during the pandemic, has NVIDIA been doing any work with COVID-19 In terms of applying their technology?

Justyna Zander
Oh, yeah, absolutely. NVIDIA is a fantastic company. And I've seen a lot and I've been to many companies, as you said, and NVIDIA is extraordinary for two reasons. One, it goes very, very fast. It only engages in things that are very difficult to achieve, and then it executes very fast. But, two, NVIDIA cares, and NVIDIA actually builds things that are relevant for humanity. And so for COVID the was NVIDIA processes this, we obviously have to find vaccines and testing, but we also think, you know, in a broader scale, so we are donating a lot of computers to organisations that care about mitigation, and also about planning and basically researching what else could we be doing better as a humanity in terms of how we protect ourselves from events like this. NVIDIA is active on the front of all these three domains, researching the biology or the medicine around it, then mitigating and then also planning for the future.

Sue Nelson
And throughout your career have you had a mentor or somebody that you've aspired to emulate along the way. Has to be one overall influence, or maybe a family member, or several or something else?

Justyna Zander
I have this friend in Poland, from my childhood. And he always says that everybody you meet in your life is there to give you a lesson if you want to accept that. So, I think everybody whom I met, played a significant role. And of course, there are, you know, more famous mentors and less famous people who you treat as mentors. So I would say, a lot of people influenced the way I think, if I think about, you know, whom I met in my life, everybody contributed something.

Sue Nelson

You've worked at the White House, what did you actually do there?

Justyna Zander

So at the White House, it was a Smart America initiative. It was like a DARPA challenge but organised by the White House. And so for the Smart America challenge, the main priority was 'show us the glimpse of the future, and how is it going to positively impact the future of humanity'. And what we built was a smart Emergency Response System, which is kind of handy in those times today. But we built it for the earthquake scenario. So we basically combined multiple, various technologies in one big system that could help us in case of an earthquake scenario or an emergency scenario. And the way we did it was we combined humanoids and robots and drones that would be used as devices that help everybody who is a victim of earthquake and go there based on the Command and Control Centre. So basically, we would collect information from the field from people who are endangered and then the Command and Control Centre would send and dispatch all these devices to people with either supplies or with some kind of devices to get people out of the buildings or help them get out of the buildings, provide food, provide medicine, and even provide other humans who are doctors and so on. And we actually won that entire challenge out of will nine organisations across the globe.

Sue Nelson

Congratulations.

Justyna Zander

Winning the challenge in the White House. It's a nice, you know, five minutes and you get the cover in all the articles and publicity, and then I tried to commercialise the solution and it turns out nobody really wanted to invest in the humanitarian action. We are living in the capitalistic world. So humanitarian cause is not necessarily something that is going to bring you capital or benefit in terms of finances. And so the project unfortunately had to stop. And it's still in my mind, but it's on hold.

Sue Nelson

It sounds like the word it keeps coming up is humanity and helping people. This seems to be a driving force in terms of what you want to do.

Justyna Zander

Yeah. And wouldn't that say helping, I would say advancing or just using whatever we're building in the capitalistic world, using it in such a way that it's gonna advance people. You know, I had that conversation with my other friend the other day, and he said "you know what, I think the world 50 years ago was just fine without all this technology that you're building". And he's not in technology but a completely different industry. And I gave him the thought that in a sense, from one perspective, he's right. So, it's true that we are advancing but is it bringing more happiness to humanity? I mean, you have to think about various factors and of course, happiness is different for everybody, but I'm not sure. So, it will be good to, you know, to have a lot of people who are thinking how to advance humanity and how to advance society so that we are actually making something good to each other and to ourselves, as opposed to just advancing without the bigger purpose.

Sue Nelson

So what do you think a driverless future will look like? Will it be the way it's depicted in science fiction or will it be a lot more down to earth and that?

Justyna Zander

I don't know what science fiction you're referring to. I actually don't watch TV that much. I only recently started watching a little bit more.

Sue Nelson
Too busy getting degrees.

Justyna Zander
Maybe I'm just too busy doing other things.

Sue Nelson
Yeah. But do you think there'll be a point where people still want to, a bit like the fact that say electric hybrid cars a very popular, will that sort of hybrid driverless car do you think be the one where people can still retain control if they want to or switch over or what have you?

Justyna Zander
So it depends on the time horizon that we are talking about, I think in the next 25 years, there will be a lot of cars that you can drive yourself still, and it depends on the geography as well. But at some point, we are probably gonna migrate to this model that it's just like a transportation on demand. And it just takes you everywhere, wherever you want. But it's gonna take us some time. I mean, if you look at the IT systems, the way we build these systems, some of them are very robust and reliable, and some others are not. And so, the driverless technology is going to be very similar that we're gonna slowly adapt depending on the geography governments and you know, humans who are using it. It's gonna take some time.

Sue Nelson
What would you say if you were to encourage people to study engineering, maybe to follow your path into automation and driverless technology and AI and deep learning. What would be your pitch, why would you say it's such a good career to follow? What is it about what you do that you enjoy?

Justyna Zander
I would tell people to do whatever they love, whatever they enjoy whatever, they wake up with passion and feel like yeah, I want to do it. And it doesn't necessarily have to be engineering. It could be anything. I think in the future, it's going to be much more artificial intelligence and data science combined with engineering. If I were to encourage someone, I would just think what motivates you just sit with yourself and be honest with yourself. What do you really like doing? I know about myself that I just like building stuff. I like building stuff at scale. I don't want to just sit down and build a little robot. It's my home. I actually didn't do it when I was a child. So, I just want to you know, it's like when I think what is my future. I would love to have very safe supersonic flights. I just so much enjoy this idea. So, if I could build that I would do that.

Sue Nelson
And how do you relax? I suspect the fact that you're a licenced Zumba teacher has something to do with your choice of relaxation.

Justyna Zander
That's true. Zumba is a is a form of dance. I think dancing is occupying a lot of my free time. So I do relax through dancing. I do relax through sport.

Sue Nelson
What style of dancing and sport?

Justyna Zander

I used to do ballroom dancing when I was at MIT. I really like the technique of dance. And then I learned about Zumba. After that my friend from Poland actually took me to a Zumba camp one day and I fell in love with that because it makes you independent you can you can do Zumba anytime, anywhere. And it combines Cuban and Brazilian type of dance with more modern music, you can express yourself, you can be yourself and you can, you know, get some activity out of that. What I like about Zumba the most is that it's a group sport, but at the same time, you can stay independent. So you're not dependent. You don't need a dance partner, but you do it within a group. And I strongly believe that humans don't mean that much when they're just individuals. I actually think that people mean much more when they aggregate in a group so when you have 20, mostly women dancing, Zumba, it's very empowering to do it together. It's very empowering to see other people enjoying it and having fun together. It's a big thing.

Sue Nelson

And sport what sort of sports do you do?

Justyna Zander

Biking and skiing.

Sue Nelson

You do it all! It's fantastic to speak to somebody who's got such a you know you obviously love what you do. Mind you, I don't think I've not spoke to anybody yet who doesn't really enjoy what they do and has also got that lovely sporty dancy side of it, too and living in California. I mean, what's not to like?

Justyna Zander

It depends on your priorities and what you like in life. I think every human has something about themselves that is very unique, and you can explore it. Everybody has something to contribute, and everybody has something very, very interesting about your life. It's just a matter of how deep we want to go.

Sue Nelson

Well, your life is absolutely incredibly and interesting. Justyna Zander, thank you very much for joining me on the Queen Elizabeth Prize for Engineering Create the Future podcast.

Justyna Zander

My pleasure. Thank you very much Sue.