**CRAIG:** Hi, I’m Craig Smith and this is Eye on AI.

Since 1996, the XPRIZE has encouraged technological development to benefit humanity through incentivized competition. This week, I talk to Jacki Morie, a senior XPRIZE advisor about the ANA Avatar XPRIZE, a competition focused on creating an avatar system that will seamlessly transport human skills and experience to distant locations. The four-year competition is in its final stretch.

Jacki, who has spent her career in creating immersive VR environments, talked about the state of the art in robotics, the challenges of two-way communication of sensory data between human operators and robot avatars and the hope that the ANA Avatar XPRIZE will spark a industry asXPRIZE has helped do with commercial space travel.

Again, I want to thank our sponsor, ClearML, an end-to-end MLOps solution. Please check them out at clear.ml and tell them Eye on AI sent you.

Meanwhile, I hope you enjoy the conversation with Jacki as much as I did.

**CRAIG:** Jacquelyn. Why don't you start by introducing yourself, your association with XPRIZE a little bit about XPRIZE and then specifically about this particular prize.

**JACKI:** Hi, I'm Jacki Morie. I am a consultant on the ANA Avatar

**JACKI:** XPRIZE I've been involved with this prize for about four and a half years now, and it's really exciting to see it come to its real big conclusion. What we hope will be a big conclusion. XPRIZE, as you probably know, incentivizes teams around the world to work on really hard problems. So, things that are almost unattainable and this prize is certainly one of those to create a tele robotic avatar.

**JACKI:** That someone can control from a distance and feel as if they are truly there getting all of those sensations back like the visuals and the sounds. But beyond that, even the haptics, so that if you touch something with your robot in the physical world, at a distance, you are feeling it wherever you are controlling that robot.

**JACKI:** As I said, it's been four and a half years since we started this prize, and we are now converging on the finals. We had started with about 99 teams globally. And we are down to our 20 finalist teams. They have all been working on these tele robotic avatars, and they all have very different and amazing solutions.

**JACKI:** And we're going to see those in action at the finals scheduled for Long Beach, California. The beginning of November and the public is invited. So, you can come witness what these teams have been working on for four and a half years.

**CRAIG:** Wow. That's exciting. Can you put the prize, this avatar prize into a little bit of context, give a little bit of background for those listeners that don't know XPRIZE and then how many competitions or prizes you have running concurrently?

**CRAIG:** And what is ANA, which is the Japanese airline, what is their interest in sponsoring this particular prize?

**JACKI:** So, XPRIZE from the very beginning has tried to incentivize really hard problems in the hopes of starting new industries. the very first one, 20 years ago, or so was the Ansari XPRIZE which challenged people to take people for three orbits in a private spacecraft, come down and do it again in a few weeks. And it was a public event where people came, and they cheered on their teams. And that really was the start of the commercial civilian space industry that we see today everywhere around us.

**JACKI:** If you want to see the kind of prizes that we have right now, and again, it's a 20-year history that XPRIZE has sponsored. If you just go to xprize.org, you will see the ones that we're currently involved with. One of the big ones is the rainforest XPRIZE sponsored by Elon Musk. We also have a big carbon prize that Musk sponsored. So, we have a couple big ones out there. Some of them are just starting. So, none of them are at the same phase. Avatar is just finishing up on this competition.

**JACKI:** Now, why would a Japanese airline decide to get into this business. It's a little crazy, but ANA, the All-Nippon Airways, their business was not about flying people around in tin cans, it was about connecting people. And so, the ways that you can connect people today because of technology are much more advanced and much more personal, if you will, than putting people in a, basically a flying bus and sending them somewhere.

**JACKI:** So, they're trying to get in very early on this new technology that will help them connect people the way they see that their core business is.

**JACKI:** XPRIZE was started by Peter Diamandis and there is a foundation that is behind the competitions. The foundation is all about having an impact on the world. The prizes are part of that work. So much of the funding for this comes in from sponsors for the prizes, but there are other operational costs for the foundation as a whole.

**CRAIG:** And for those who don't know, Peter Diamandis is a Greek American engineer, physician, and entrepreneur. And he's also co-founder if I'm not mistaken of singularity university, is that right?

**JACKI:** Yes. He's founded a lot of things. So, singularity university, the longevity Institute, XPRIZE he's done a lot of things in his life to help technology have a really powerful impact on the world.

**CRAIG:** You mentioned haptics. Do you know how many of the entrants are integrating haptics into their solutions?

**JACKI:** About a third of them had haptics for the semifinals, which were held last September in Miami, Florida. for the finals, if they really want to win, they're going to have to have haptics.

**JACKI:** So, we've been working very hard as the operations team and with our expert consultants, our judges to look at what haptics tasks we're going to put in those finals, because again, they're going to be open to the public, so we're going to have an audience. So, they have to be very clear that they are actually using haptic technology.

**JACKI:** We have some teams that are really powerful in that area that have made advances in haptics. So, we're excited to see what they're going to do.

**CRAIG:** Do you know what kind of technology they're using for haptics? I've talked to Peter Abbeel at Berkeley, and they use a technology they're like gel

**JACKI:** bladders pads?

**CRAIG:** Little bladders pads, exactly. With an electrode in it that reads the increase in pressure. I don't know that they use something on the other end that then can transmit that to a human. I think they use it simply to give robotics a sense of how hard they're gripping something and things like that.

**CRAIG:** is that the dominant technology and how do you transmit that to a human, do they wear a suit that then, has bladders that, that inflate or something?

**JACKI:** you've touched on the hard problem for this competition with haptics, and that is the two-way communication. So, haptics communication for a robot has typically been on the end effectors of the robot.

**JACKI:** And typically, in that sensibility of what the hands are touching the texture or the pressure or the force feedback, there are really about 12 different vectors for haptics. And we're only testing a few of them. There are sensors that just use the fingertips.

**JACKI:** And there are sensors that use the whole palm, typically with these little air bladders that are controlled for feeling some kind of pressure on your palm.

**JACKI:** but we also have haptic suits where you are either thumped or zapped with a little electrical signal, and those can take the place of other kinds of haptics.

**JACKI:** We're not looking at the full body kind of haptics for this competition simply because it's still kind of dangerous to hug a robot. So, we're looking mainly at the ones that can be done with your hands. And those include search haptics, where you're actually looking for the object that you're trying to locate, like a smooth rock out of a bag of crazy rocks and things that allow you to figure out how much force feedback you need to press a button to make something happen, for example.

**JACKI:** Now, the two-way communication for haptics is the really critical part of this. And it's how this competition differentiates itself from almost everything else going on in robotics today. Getting those sensations back to the operator, who's controlling that tele robotic avatar. Is critical for feeling that sense of physical presence.

**JACKI:** And that's how these avatars differ from digital avatars. Digital avatars are not truly in another place. Whereas these avatar robots are so it's imperative that the operator gets as much sensation from the physicality of the robot in that different location to really feel that their body is in that different space.

**CRAIG:** I'm not sure what falls under the rubric of haptics, but I've spoken to AI researchers who have developed a system that can categorize molecules by the odor that they're likely to produce so that you search the universe of molecules and categorize them by odor even without actually smelling them. And then I recently heard from a guy who's developing an electronic nose, a sensor that can sense and identify smells.

**CRAIG:** Is anyone working on the sense of smell?

**JACKI:** A lot of people are working on it, but not for this competition. And you've just hit on one of my research areas. I've been involved in the smell for virtual reality for about 20 years now. And have developed devices that allow you to have a very safe scent atmosphere in your virtual reality.

**JACKI:** The noses you talk about are really interesting that you can get the molecules and figure out what they are. And yet we don't have an RGB of smell. So, it's really a difficult problem. It's more difficult than haptics. And haptics is pretty darn difficult. So, we did not include smell for this competition.

**JACKI:** Although for me, it would've made my heart very happy to have smell in there. a lot of the technology that the teams are doing for this is very rudimentary. When you think of this two-way communication, that has to go across a distance. So, we've minimized the problem to get the basics of the technology going.

**JACKI:** And there are some teams that are way ahead of others, but there are some teams that are coming up with little interesting bits and bobs of solutions that might not have been obvious if you had really constrained the rules for this. One of the things that we've talked about from very early on in this competition is when you have something at a distance, depending on the distance, you're going to have latency, right? If I am operating a robot on the moon, I'm going to have a big delay. This is where I see AI coming in and we don't have it for this competition because there are so many more fundamental problems to be solved.

**JACKI:** But once we tackle latency and we decided we wouldn't put it in for this competition, because again, we're doing the foundational stuff right now. But once you have latency in the mix, you're going to have to look at AI solutions to counteract that latency, whether they are predictive algorithms or. Line of site stuff or whatever those things are going to be critical to having this technology work at a real distance.

**JACKI:** You cannot have one to one communication. If you are waiting for a minute and if we're on Mars we're waiting 22 minutes.

**JACKI:** Now that's the basics. You're going to have some predictive algorithms with AI, but what I see for a real contest is how do we have these AI aspects of our robot, or our avatar be something that can learn the behaviors of the operator so that in the absence of a direct signal, we have backup.

**JACKI:** We have something they can fall back on to make that robot appear to be acting as them in real time. And that's a big problem. That takes some general AI, it takes in a lot of other aspects of AI, but this is where I see it going. So, give us 10 years and I think we'll start to address that problem.

**JACKI:** And AI is going to be a critical component of these avatars being useful for humanity.

**CRAIG:** Yeah. It's a fascinating idea. When we spoke earlier, I talked about attending the 1963 or 64 world's fair where GE had a display with, avatars that, moved and talked and things, and they were being operated by an operator enmeshed in wires that were run through the floor to this thing. And so, it doesn't seem like a huge leap to just cut those wires. that technology presumably exists to have a suit that moves the robot in the same way. Having the visual doesn't seem that big of a stretch given 360-degree cameras and headsets.

**CRAIG:** And certainly, the audio is the most basic of all. What's the state of the art right now for controlling a humanoid robot at a distance, because there's certainly been a lot of work on that before the XPRIZE

**JACKI:** the other problem, besides the distance thing is the integration of these things.

**JACKI:** And you say, vision's easy, audio's easy. But when you start to integrate them, we find that teams say, oh we don't really need high-res vision, or we don't need 360 vision, or we don't need stereo vision, they sort of lap off what they don't need to get to the bare minimum of what they need, but really for a high-resolution experience, you want really good quality audio.

**JACKI:** It should be spacialized. You want good quality visuals, and they should be conveyed back at least 4K. You want good quality touch. You want good quality mobility where the person operating the avatar can feel like they're really moving that avatar. And the solution space is just vast. So, you have VR equipment that's being brought to bear on this.

**JACKI:** Console controls don't give you the feedback of the senses to the operator. They allow you to say, okay, move my robot five feet this way or wave my hand or whatever it is. And this is back to what you saw at the world's fair.

**JACKI:** That two-way communication is the critical thing with all of the senses. So, this kind of multisensory two-way communication is where the state of the art is still out there. People are trying different things. We probably have with the 20 teams, at least 10 kinds of VR controlling units. We have people that are using omnidirectional treadmills to be able to walk.

**JACKI:** And there's a scaling problem there because you don't always get the same step size that you would get on the other end. We have people that are using game controllers. We have people that are using foot pedals. We have people that are using all kinds of things, and that's the brilliance of letting people do their own thing.

**JACKI:** We're going to see what shakes out what the operators say that was pretty good. Or I had to walk twice as fast to get half as far, those type of things.

**JACKI:** So, our operators for the finals are the judges and our judging panel of 22 people has been culled from experts in every domain of robotics, haptics, virtual reality, and other related industry

**JACKI:** and they are really smart. And they are going to be the ones controlling the robot, and they are going to be the recipient at the other end of a two-way communication thing. So, we're going to get very smart people saying that solution was pretty good, that solution. Maybe didn't do it for me.

**JACKI:** That's what we're waiting to see with the finals. What pops up as the cream of these solutions?

**CRAIG:** So, the judges are actually going to operate the avatars either by wearing a suit or as you said, operating a console. What kind of tasks will they be doing?

**CRAIG:** Do you know yet

**JACKI:** for the finals event? The way we have set it up, there is a test course run. There are three domains. So maybe one is connectivity. One is skills transfer, and one is exploration. The robot avatar will have to move from one domain to another. So, think of them as separate boxes out there on the arena floor where the finals will take place.

**JACKI:** Back in another room in the operator control room. One of our judges will be controlling that avatar with whatever mechanisms the team has given them. So, they won't be out there on the floor except through the eyes and ears of the avatar. We may have another judge that is in one of those domains to talk to the person operating the avatar, and then the avatar has to do other things.

**JACKI:** So, one of the big tasks will be mobility. Can they actually make it from one of these domains to the next one over about 80 yards, let's say, so they have to get there. Now, whether they're bipedal or they have wheels, or they have some other sort of mobility mechanism, they're going to have to do that. They're going to have to do dexterity tasks where they're moving switches or picking up something or lifting a canister.

**JACKI:** They're going to have to do some sort of haptics task where the operator actually feels those forces that the avatar is feeling. And they're going to have to do a little bit of skills transfer. It's going to boil down to 10 discrete tasks though. So, every team has to do every one of those tasks, or they don't have a shot at the grand prize, which is in the millions of dollars.

**CRAIG:** These are primarily researchers, are there any corporate teams involved? As opposed to university or research Institutes.

**JACKI:** A lot of them are university and several universities have gotten together to combine their technologies.

**JACKI:** Converge was a merger of haptics company and SynTouch and Shadow Hand. So, there were, three companies that got together to make the biggest baddest avatar you've ever seen. And they've got a lot of haptics because they brought in a haptics company as part of their consortium. Other than that, though, we see a lot of very young eager researchers who are looking to create the next best thing.

**JACKI:** And we've got teams from Italy. There's a lot of robotics in Italy. We've got teams from the United States. We've got one from Singapore, the UK. All over Europe. We have a couple from Japan, South Korea, so we have quite a few.

**CRAIG:** In the past with XPRIZES, what happens with the solutions?

**CRAIG:** Do some of them find their way into industry and products. I'm thinking of DARPA, a lot of their prizes or competitions turn into startups.

**JACKI:** That's certainly what the teams in this competition are hoping for that some of them will come away with a company that can actually be the start of this industry.

**JACKI:** Now, the way it works with the XPRIZES, XPRIZE has nothing to do with the IP. ANA gets a first look, so if there are teams that they want to invest in, they can do it, but the finals will also be open to any investors who want to come and look at this technology.

**JACKI:** And so, they are looking at have a product that could be commercialized. That's the goal. The goal is to start a new industry. And certainly, we hope that there'll be a bunch of new companies that come out of this finals event in November.

**CRAIG:** Are any humanoid robotics companies involved. Of course, I'm thinking Boston Dynamics and there's a couple in Japan. Are any of them fielding teams,

**JACKI:** not for this competition. We've talked to them. Some of their humanoid robots are just too big for what we're trying to do and stay safe.

**JACKI:** Some of the Japanese companies, unfortunately with this pandemic, it really precluded their involvement. And yet, they're all watching this and there's actually a big effort in Japan to have this avatar technology as a moonshot. So that's going to continue despite the fact that these Japanese teams who are sometimes way of. could not participate in this competition. What's great. Is that there is a burgeoning sort of community of people looking at this four and a half years ago. When I started with XPRIZE on this, a humanoid robot was really an autonomous vehicle. There was none of this.

**JACKI:** I'm going to control it as a teleoperated robotic entity of myself. That has been a huge shift that I think XPRIZE has pushed. We've now got people talking about the fact that the sensations have to come back to the person operating the robot and there's room for both there's room for autonomous and there's room for the teleoperated.

**JACKI:** And when you get down to it, there's going to be a merger of those in the future. When we really start having to solve some of the difficult problems like latency.

**CRAIG:** I'm sure you guys have thought a lot about applications. You mentioned, operating a robot on the moon or even Mars. What are some of the applications that get talked about?

**JACKI:** Many of them have to do with isolation. So, you can go visit a relative who is maybe in a care facility or that you can't travel to see. The pandemic has opened up all kinds of new opportunities for that kind of communication that has a physicality. Everybody wants to hug their grandmother, but they can't.

**JACKI:** So, we're not there yet, but that's where it's going. That we will be able to do that sometime in the future. So that communication with another human being, which we call connectivity, that's a really important use case. Beyond that there are all kinds of exploration things. If I want to have a more humanoid robot on the moon, that can feel the texture of rocks that's another one, but also to go into places that are too dangerous for humans, where the human form actually is a benefit because we have a lot of robots that can go underground and they're just little boxes and things like that. Or maybe spot the dog form is the best form, but there are going to be occasions when it's the human form that is really important and critical for a particular application.

**JACKI:** The other one we have is skills transfer. And that one human form is even more important because you're trying to do something that a human would do. And even with the DaVinci robot, you still are manipulating things in a way that enhances the human capabilities. So, when we have these avatar robots that have a humanoid form and we go to do skills transfer, whether it's a doctor popping into a robot in a remote village to perform some kind of operation or Tapping on the person doing percussive medical exams.

**JACKI:** The human form is going to lead to greater adoption for other communities that may not really want to robot dog in their midst. They want to have some sensibility that there is a person behind this. We have not emphasized making really realistic human robots because that's hard.

**JACKI:** But when we want to go for mass adoption, when we want to go for the trust factor, when these robots are in use, we're going to want to have something that conveys emotion, caring, and communion with the other person.

**CRAIG:** Robotics are fascinating. Something that moves autonomously, or at least without someone physically moving them in front of you, you invest it with personality. When I first got a Roomba, and it got stuck and was bleeping, I, I felt sorry for it., you don't need a full human, like avatar to have people react with some emotion.

**JACKI:** This is actually an interesting research area. When that Aibo dog came out, I bonded with that dog. And as humans, we tend to anthropomorphize our machines. But there is a vein of research we have not really cracked yet, which is what is it that allows us to build that trust.

**JACKI:** With a machine. And is it your empathy or is it something the machine can evoke from you? And so that's another thing I see happening in the next 10 years where we really crack that nugget. What is it that allows us to trust and use these kinds of machines for our benefit?

**CRAIG:** A lot of the challenges it seems to me is in the miniaturization of motors and the dexterity of robotic hands and things like that because even today, most robots, even in research institutes are using grippers, too. Pronged or three pronged grippers. How far do you think we are from developing that kind of nuance in movement?

**JACKI:** We are seeing in our teams, a lot of hands, they might have one hand and one gripper. But hands are certainly becoming more prevalent. And I think that's not only because of the kind of tasks we want them to do, but because it's a hard problem to solve all of those actuators, that's another entire vein of research and thank goodness there are people looking at those mechanical aspects of the robots and how those can be made better and more controllable. So, all of these things together make this problem extremely hard, but I do think when you've got people to people and you're using an avatar to create that connection, whatever looks more or feels more or can be believed to be more about the human at the other end, that's going to make it easier to adopt that technology. So, hands are important. Hands are hard, but they're very important. We still are looking at metal hands, but very articulated and much finer control than we had a decade ago.

**CRAIG:** You're watching the field develop. How long before there will be a humanoid bipedal robot that someone could control, remotely, let's say in a factory to do things that require some dexterity.

**JACKI:** I think we're starting to see the humanoid type of robots in the service industry. In Japan, there are ones that can serve you coffee, or be controlled by somebody at the other end who doesn't have full mobility. And yet they can work as someone in a coffee shop or whatever.

**JACKI:** So, we're starting to see it in the service industry. And I think that might be the first step. Beyond that the healthcare industries that's very important. Again, Japan has an aging population. This is why they've put so much effort and focus on these kinds of robots that can help with that aging population.

**JACKI:** So, I do think the first round of these entities coming into use will be something that involves other people. So, whether it's service industry or healthcare, that's the first part, then I'm hoping we get into the skills transfer, because I think that again is incredibly important. If we can start to train people all over the world or.

**JACKI:** Even have that expert who can't travel or it's too far for them to meet an emergency, be able to jump into one of these avatars. I think that's going to be very beneficial for the world.

**CRAIG:** And You see that developing in five years, 10 years. I know people hate to make predictions.

**JACKI:** Yeah. I don't know if I'm going to make a prediction, but I think ANA would like to see it happen within five years. And I think, they have their own company avatarin and that's their verb for coming into one of these avatars in a teleoperated thing you're going to avatarin to the robot.

**JACKI:** They're already planning for this and yeah, it's going to be rough at the beginning. It's not going to be everything. But I'm hoping that in five years we have at least a dozen companies looking at this problem and coming up with solutions. And then in 10 years, I think we will have figured out some of the things that really work, whether it's the form or the kinds of mechanical aspects, you need to support that.

**JACKI:** Or what's the best combination of audio, visual haptics that you need. And let's add smell in there in 10 years. I'm going to put that in there. So, I think in 10 years we will have a really good start to an industry. I think it may take 20 before it's widely accepted. And when I say widely accepted, I mean, places where they're either the most need or the most technology savvy people.

**JACKI:** So, I think that's the start beyond that. I'm not going to predict, but let's say in a hundred years, these things are everywhere and it's just part of our everyday reality.

**CRAIG:** Yeah. I'm hung up on the engineering of the robots beyond the hands and the dexterity every robot I've ever seen outside an industrial setting moves relatively slowly. I know Boston dynamics has Atlas running and things like that, but is there a reason why everything is so slow? Is that a hardware problem? Is that just a safety issue and can that be solved where beyond dexterity you have human-like speed.

**JACKI:** We have a lot of joints as a human, whereas a Puma robot on a factory floor making a car, only has a few joints. They just got to do one thing over and over again. So, it's a very limited solution space. Whereas humans, we've got all kinds of joints and even our hands are massively jointed.

**JACKI:** So, it's a big engineering problem now, can we make it faster? Yes. I don't know if you've seen Disney's stunt double robots, those are pretty fast. Jon Snoddy, who is head of Disney research and oversaw the stunt double robot projects is one of our advisors on the ANA avatar XPRIZE. So, you can make them fast if they're doing particular task.

**JACKI:** So, you've programmed them to be able to do that quickly. It's when we get into the general purpose. That it becomes harder because you can't anticipate exactly what that robot's going to have to do. So, you have to build it. You have to engineer it; you have to make all the joints and things flexible enough so that they can accommodate any behavior that a human is trying to put into it.

**JACKI:** And it's still a hard problem. We've figured it out for digital animation and that's taken us 30 years. So, imagine what we're going to get in 30 years when we get the hardware engineered to the point where we can really make it sync.

**CRAIG:** I had on the podcast a couple of years ago, a woman named Aude Billard from Switzerland, ETH the big Swiss Institute.

**CRAIG:** And she had been working on computer vision and robotic arm. She could throw the robotic arm, a half-filled bottle of water, which tumbles in an unpredictable trajectory. And this robotic arm could snatch it out of the air. It was really impressive.

**CRAIG:** Are the Swiss involved at all? They're famous for their precision mechanics, certainly.

**JACKI:** So, I think ETH might be a partner with one of our European university teams. There's one I know that has five partners and I'm pretty sure ETH is part of that.

**JACKI:** So certainly, if the Swiss are not involved in this competition directly, and they may be in partnership with one of our teams, they are doing this on their own. And they have been part of some of the Disney research. So, Disney really funds them to do this research. It may be where some of the functionality of the stunt double robots came from.

**JACKI:** They're certainly looking at a lot of problems at ETH and lots of things need to be solved, but great stuff coming out of that lab.

**CRAIG:** Okay. I'm running out of questions, is there anything I haven't touched on that you'd like to talk about.

**JACKI:** We would like to invite everybody that can make it to Long beach.

**JACKI:** The beginning of November to come to the finals event, it's going to be an open, free event. All you have to do is go to xprize.org and look for the avatar XPRIZE and register. And then that'll put you on a mailing list. So, we'll let you know what's happening, but we are going to have over two days of public events, all of the teams who qualified to do those last finals test course run. They're going to be doing it in front of an audience. You can root for your team, and they'll be right in front of you in a big arena as well. We're going to have a big expo for the latest in robotic technology, especially the humanoid robotic technology that this competition is fostering.

**JACKI:** So, it's going to be a great event in long beach, California, November 4th and fifth. Do try and come to that and go register for this event.

**CRAIG:** That’s it for this episode. I want to thank Jacki for her time. I encourage everyone listening to visit Xprize.org and register to attend the avatar finals in Long Beach, California in November. I hope to be there myself. If you want to read a transcript of this episode, as always, you can find one on our website, eye-on.ai. I also want to thank our sponsor ClearML for their continuing support. If you need an MLOps solution, check them out at clear.ml.

And remember, the singularity may not be near, but AI is about to change your world. So, pay attention.