Raja Kadiyala: Yeah, in transportation sector, we're actually developing digital twins to aid construction workers. So as the crews go out, we're finding giving them a digital twin and actually putting goggles on so they can actually get a better feel for what they'd be doing out in the construction zone. It gets them better prepared, which really improves worker safety.

Stephen Ludwig: Welcome to Inflection Points, a podcast series from Jacobs. I'm your host Stephen Ludwig. That was Raja Kadiyala, Vice President Global Director for Digital Solutions. What if you could predict a problem at a facility before it even happened? It sounds like science fiction, but it is actually cutting-edge technology called Digital Twins. Raja walks us through how digital twins can be applied to industries and communities, making them safer, increasing efficiency, and improving the environment. It's pretty cool. Inflection Points is where we meet the people of Jacobs that help create solutions that deliver a more connected sustainable world. Just a quick note, we recorded today's episode at a conference, so you may hear some background noise. With that out of the way, on with the podcast.

Raja, what's your background?

Raja Kadiyala: So by education, I'm electrical engineer. I did my Bachelor's and Master's and PhD, all in electrical engineering. I actually specialized in robotics and control theory.

Stephen Ludwig: Well, how interesting is that?

Raja Kadiyala: It's not your typical background of somebody at Jacobs. Yeah.

Stephen Ludwig: How did you wind up doing the kind of work you're doing now?

Raja Kadiyala: So, it was my background within control systems that ended up linking me to CH2M Hill. So I came in through that organization and started off as a control system engineer.

Stephen Ludwig: And then you're doing what you're doing now.

Raja Kadiyala: Doing what I'm doing now, which is the Global Director for Digital Solutions. We focus on a number of core technologies that include AI, artificial intelligence, data analytics, optimization control systems as well, and, our Digital Twin efforts as well.

Stephen Ludwig: How far are, is Jacobs and the world with AI? I know there's a lot of talk about it. Is there more talk right now than actual execution or where do you see it going?

Raja Kadiyala: We are implementing AI solutions right now, and there's certainly other companies that may be able to implement AI systems in general. They have

more capabilities than us, but our focus is on utilizing AI for the built environment.

Stephen Ludwig: Which is? What's a built environment?

Raja Kadiyala: A transportation system, a water system, buildings, smart cities. That is where our domain expertise really lies. And our ability to leverage that domain expertise to help train the AI systems is really our differentiator in that space.

Stephen Ludwig: So how is AI helping someone run a building or water plant or something like that?

Raja Kadiyala: So we have an effort going on in Australia where they have a chemical dosing system. So something that adds chemicals during the treatment process. And they're being very conservative in terms of the amount of chemicals they use to make sure that they meet the regulations. And it's ending up, costing them a fair amount. So we actually have an AI algorithm that's taking a look at the water coming in and doing a real analysis of what you need to do to that water to meet the regulation requirements. And we're saving through that AI algorithm about 12% and usage fees. So that's kind of how in one way that we can impact the water sector.

Stephen Ludwig: That's really fascinating. And it also probably makes it safer for the public having that AI help make decisions based on what data is coming in.

Raja Kadiyala: Exactly. You're putting in the right amount of chemicals to treat that current situation or that current water quality that you have.

Stephen Ludwig: You mentioned something earlier about digital twining, what is a digital twin? It sounds like something out of a creepy horror movie.

Raja Kadiyala: And I got a tread lightly here because I'm actually the father of twins. So, a digital twin is a replica of a physical asset, process, or a system where we're able to do scenario analysis. So try out different things in the context of within the digital environment, and then apply them to the physical system, or be able to forecast going forward what may happen to that physical system by again, looking at the digital replica of that physical system. Or lastly, check for abnormalities, is there something happening now on the physical system shouldn't be happening? And we can all do that by running that digital twin in parallel, essentially, to the data that the physical system is receiving.

Stephen Ludwig: So if I'm understanding correctly. A Digital Twin is... Do you go in and scan a facility like a water plant or an industrial facility, and then digitize it and put it in to the computer and make it smart. So you can run simulations on the digital twin and then bring that back into the plant?

Raja Kadiyala: Yeah. We kind of break things down into three categories. What you just referred to there is something we call a Layout Digital Twin. So it is taking that layout of the plant and being able to digitize it. So you can actually have it in the digital format. Then you start getting into something that we call a Process Digital Twin. By being able to actually take a look at the underlying processes that are occurring within that facility and simulate them, build models of them. The last category for digital twins that we like to use, is a Data-Driven Digital Twin. So here we have a pile of historical data that you've collected over time. And we utilize that then to build an AI neural network. A digital twin that's based on the historical data and the outputs that you received with that historical data. So that is totally just looking at the data. And then in that middle tier, we're applying our, our domain knowledge to build those simulation models for the Process Digital Twin. And in that initial tier, it is that layout more the design Digital Twin.

Stephen Ludwig: So help me understand what processes you would look at on a digital twin point of view?

Raja Kadiyala: So we just talked about that water treatment process as an example. So here, they were utilizing our fundamental knowledge of the treatment process and our [inaudible].

Stephen Ludwig: So we'd see the water come in, it gets tested, you add chemicals. It does something else. I don't know anything about water processing I'm just guessing here. I've been to waste water treatment plant, but that's about it.

Raja Kadiyala: Well, we know how given the various water quality scenarios, how we can actually then add the chemicals to then bring it into regulatory confines. So our understanding of how the chemicals react with the water and to bring it into the proper range is kind of one element of our domain knowledge in that process side of the fence.

Stephen Ludwig: What's another process, like a chemical processing plant would be a similar idea. You know how it gets if you have X to begin with and you add Y you know, you're going to get Z. And you can run that simulation on the computer side?

Raja Kadiyala: Right. And what we're doing is we can actually run in the digital side, run a whole bunch of different scenarios in conjunction with what's happening on the physical side. So we can go through a thousand scenarios and say, "Gosh, if those a thousand things that we just ran, what do we really want to do?" So we can, we can take the optimal solution of those a thousand and actually apply that. And then five minutes down the road, you do the same thing. So our ability to have that digital replica of the physical system allows us to kind of run all these things faster than real time, and then apply them in real time.

Stephen Ludwig: That's fascinating. Like you could really make it like, oh, it's shifted in the last 10 minutes, we're going to be shift now. And you run the X number of scenarios in a heartbeat?

Raja Kadiyala: Exactly.

Stephen Ludwig: Yeah. That's very interesting. The Data Digital Twin sounds also really interesting, especially for companies with a lot of legacy information, either digitized or not digitized and you help them out with that. That sounds like big data and data mining. How do you help clients figure out what they've got and what that stuff tells them?

Raja Kadiyala: Well, it's interesting. If you take a look at the machine learning pipeline, so what is the process to actually get a machine to learn. 70% of the effort is with what I call almost data wrangling. So it is getting that data into the proper format, doing the proper QA/QC, doing something called labeling where-

Stephen Ludwig: Is QA/QC quality control... quality assurance, quality control?

Raja Kadiyala: Exactly. Making sure that we have quality data to drive that machine learning process. And then another element is called data labeling, where we have data and then a certain outcome. So we wanted to find that outcome. So we've labeled that outcome associated to that input data. So getting into that format, oftentimes it's 70% of the effort. Actually, training it once you have that data, these days is down to almost a click of the button and then it becomes validation to make sure that the model actually fits. So we can certainly help a client kind of sort through that data wrangling process, to be able to then properly train the system.

Stephen Ludwig: Of these three areas we talked about that you shared with us, the Layout Digital Twin, the Process Digital Twin, and the Data Digital Twin. How do you see any, we can pick anyone because that's a lot, what are some industries that haven't taken advantage of it yet that could?

Raja Kadiyala: Well, all of them. Yeah. All of them definitely can benefit from these various incarnations of a digital twin. Some industries have jumped more on the bandwagon. When you think about our work in advanced facilities for like life sciences or the electronic sector. When you take a look at their processes, anytime they have downtime, well that's costing money. They're not making product. So you do have application of some of these elements to start detecting when something going to fail before it actually fails and give you time to actually go in there and do some maintenance to avoid the longer downtime. We had a situation for a client in the Phoenix area where they had a repeated failure of a particular critical asset. So we were able to go in and identify what was leading up to that failure and actually give them upwards of a 50 day notice that something was going awry so that they could actually go in and do some maintenance to avoid that downtime.

Stephen Ludwig: You mentioned a number of things where digital twinning can help industrial areas with layout design, and Layout Digital Twin you can help them figure out how the plant operates. And you talked about processing design digital twining, and how that helps, and the Data Digital Twin. What are some challenges that clients are facing are these digital twins helping solve?

Raja Kadiyala: Sure. One thing that we haven't talked about is how we utilize digital twins within buildings. We're actually able to model pedestrian flow through a building. And while we're in there during the design phase, modify the design, be able to change things around if we see excessive queuing or blockage, we want to make sure that if there's emergency that everybody can evacuate a sports stadium ,as an example. An effort we did for the Pentagon, we applied that digital twin into the simulation technology to be able to reduce queue times at any of their major tech points down to two minutes. So you talking about a huge facility with a lot of traffic flow coming through. So here's where you can really start affecting things early on in the design phase, by having that digital twin in place.

Stephen Ludwig: I could see that being a transportation thing as well, like figuring out rush hour and traffic light timing and that sort of thing. Is that accurate?

Raja Kadiyala: Yeah. So at the front end we can do so many things during the design phase to look at different scenarios. The realm of scenarios that you can look at now, as opposed to in the past is really expanding. And that's how the Digital Twin is applying itself during the design phase. And then when we get to that operation phase, we can actually start monitoring the system and looking for abnormalities through the digital twin as well. So you can kind of see how it starts touching the different components of the life cycle of an asset.

Stephen Ludwig: Where do you see this technology going forward, the next five or 10 years? Anything beyond that's kind of hard to guess, but this digital twining effort.

Raja Kadiyala: Well, the application of these digital twins in real-time. Some of these simulation models that get utilized are great for scenario analysis, but being able to apply to real time is a little challenging because it takes some time for some of these models to actually spit out numbers. So we're looking at how we can link IoT data. So data coming from sensors in real-time as a starting-

Stephen Ludwig: IoT meaning?

Raja Kadiyala: Internet of things. So sensors that are feeding in information about the environment, traffic flow, water quality, et cetera. So if we can have those coming in in real time, then we can convert those digital twins into AI models and neural network models that are starting with that sensor input. And then being able to project out for the next 10 minutes, what's going to be happening and go through all of those scenarios very quickly. And then we redo that in another 10 minutes, because we get another batch of a data from those sensors

that allows us to kind of recalibrate things and again look over for the next 10 minutes. Historically, you wouldn't have been able to do that because if you run those AI models over a very long period of time, they tend to drift. So here we're kind of recalibrating very quickly. So it allows us to use those models that we can on much faster without the drift concerns, which we historically would've had to have done through those more deep simulation models.

Stephen Ludwig: So for example, if I'm hearing you correctly, I could be a city manager anywhere in the world and we've got all my traffic information plugged in and the lights are plugged in, we have the censor in the cars. And I could change how the traffic lights are working in real-time to deal with certain traffic conditions.

Raja Kadiyala: Exactly. And what's going to be happening is, the infrastructure is going to start talking to the cars as well. So as I'm driving along, the posted speed limit may be 45 miles an hour, but we'll actually be able to tell a car, "Hey, go and slow down to 30 miles an hour", because that's going to improve the overall flow because we're not getting these stop and go accelerate decelerate situations, which also has an incredible impact on the pollution within the city. And all these things really start tying together our ability to manage that flow by having those sensors, by having the AI and being able to communicate back to the vehicles, either a driver or an autonomous vehicle. We would really be being able to impact the overall environment within a city.

Stephen Ludwig: It sounds like something really exciting to work on.

Raja Kadiyala: And that's what has kept me here at Jacobs. Being able to make impactful changes in society.

Stephen Ludwig: So it sounds like digital twinning is a really good way to save money in the long run. What are the type of savings you're seeing facilities say either water waste water or industrial facility or something else?

Raja Kadiyala: So it all depends on the particular use case. I mean, we did talk about the water example, where we're saving a 12% in an energy [crosstalk] consumption.

Stephen Ludwig: That's significant for a large processing. That's a lot of money.

Raja Kadiyala: Yeah. Then the other element that you can always look at is energy consumption. So we've had situations where we've been able to save 20% in terms of electrical consumption on an effort down in Dallas. And that ended up being over a million dollars in a year. So that 20% really adds up. If you take a look at California, the largest user of electrical energy is actually moving water around the State. It's quite intriguing. So if we can optimize through a digital twin kind of that movement, still meet the demands and curb that electricity use that has huge impacts to the utility.

Stephen Ludwig: I would also mention, you mentioned the environment part. If you're using less energy, that's better for the environment as well, right?

Raja Kadiyala: Yeah. Something is out there generating that electricity. So unless you're totally on renewables, there's an impact there as well.

Stephen Ludwig: How does digital twining help a company or a government agency with safety concerns?

Raja Kadiyala: So in our transportation sector, we're actually developing digital twins to aid construction workers. So as the crews go out, we're giving them a digital twin and actually putting goggles on so they can actually get a better feel for what they'd be doing out in the construction zone. It gets them better prepared, which really improves worker safety. So we can be really impactful in terms of our clients and their crews out there. We can also start doing studies in terms of pay. If we add additional lighting here on this curve, or if we bank this slightly different, how does that impact the driver safety on that stretcher road? Again, it's going through the ability to go through all those scenarios, many more scenarios that we could have done in the past during that design phase, when we can impact it.

Stephen Ludwig: Wow. That's really, really interesting. Why do you think some people are not using this technology that's available? Is it price? Is it they're not familiar with it? Is it some other reason?

Raja Kadiyala: I think it's a familiarity and whenever you're introducing change in a process, there's always a little bit of resistance. So getting some of those lighthouse examples that we just talked about out there and communicating will begin to shift that resistance.

Stephen Ludwig: Now there's been a lot of talk about the switch from 4G cellular service to 5G service. And there's been a lot of hype around it, but is that technology going to help make digital twins better or more effective? And if so, how so?

Raja Kadiyala: Well, if we can start getting more real time data fed in, that certainly helps drive that utilization of those kind of data-driven AI models that we're beginning to link into digital twins. The other element that comes into play is with the difference between... One of the differences between 5G and 4G is. What's virtue is the communication latency. So that's the delay in getting data from one point to the other, that has drastically shrunk when you take a look at 5G networks. So, the reduction of that latency also helps us with regards to the digital twin if we want to go ahead and apply real-time control or real-time activation of assets.

Stephen Ludwig: Why is that latency such a big deal?

Raja Kadiyala: Well, if we have autonomous vehicles and if we're driving from a latency of hundreds of milliseconds, and then we are able to bring that down into a handful of milliseconds, that has a huge impact in terms of you dealing with icy road conditions or other situations that really require a quick turnaround on that communication cycle.

Stephen Ludwig: Why is this digital twin, all the work that you're doing important for Jacobs?

Raja Kadiyala: So as Jacobs really wants to help out in that connected enterprise scenario, the Digital Twins is an incredible and important piece because it really does allow us to embody all our domain expertise in these digital twins. And allows us to provide clients with that embodiment of our domain expertise to then be able to help drive different outcomes for them. So when we think about how we can impact our clients, it is our domain expertise. And utilizing that and encapsulating that in the Digital Twins really does provide that value.

Stephen Ludwig: And it does sound like it touches, you mentioned government, so the Pentagon. I'm sure there's a bunch of other things we didn't talk about air transportation and that sort of thing. And then traffic we talked about, and we talked about water, even moving water around how they can be... how you treat water. You mentioned the Australian thing. I mean, it seems to have this massive impact that we don't know the end of what the digital twining can help with.

Raja Kadiyala: Yeah. You'll eventually see a point where a majority of the systems are buildings and facilities within a city have some sort of digital twin and think about the emergency preparedness elements of that. Gosh, when Houston had the flooding from a few years ago, that was all unexpected. They didn't think that'd be hitting Houston in the way it ended up hitting them. So going through having a digital twin of all their assets or facilities to understand how they could properly evacuate, how they could potentially hold back some of what was hitting them. The scale of this and down the road is going to be incredible.

Stephen Ludwig: So it sounds like it can help with safety, help with environment and quality of life, especially with traffic, and there's all sorts of applications. It's really fascinating.

Raja Kadiyala: Yeah. And, help on the commercial side the pharmaceutical production, the semiconductor fabrication, a lot of different use cases that we really comply the digital twins for.

Stephen Ludwig: Now, is there anything I forgot to ask you about because you're the expert in digital twining and I am not.

Raja Kadiyala: So, what does it take to actually develop and implement a digital twin? So we have expertise around the globe that we end up leveraging. Depending on the use case or the particular market segment, we may bring in a transportation engineer that kind of understands some of the underlying dynamics in there. If

it's a pharmaceutical processing line, we are able to bring in that domain expertise to be able to kind of define again, the dynamics that we can then utilize within the digital twin. So the unique thing that Jacobs has is that global reach across all these various resources, to be able to bring them in and help our clients. And, as we span across all these sectors that we just talked about, having that capability to be able to define the digital twins is pretty darn important.

Stephen Ludwig: That sounds really interesting. Where can people find out more information about this?

Raja Kadiyala: So there's a lot of great content on jacobs.com and we continue to put more and more out there all the time.

Stephen Ludwig: Great. Thank you. This is super interesting. Thank you so much for being here.

Raja Kadiyala: Great. Thanks.

Stephen Ludwig: Thank you for listening to Inflection Points, a podcast series from Jacobs to find out more, please visit jacobs.com. Jacobs. Challenging today. Reinventing tomorrow.