Constellations Podcast

Episode 190 – AI Hallucinations, Blockchain and Extracting Intent

Speaker: Al Tadros, Chief Technology Officer, Redwire – 19 minutes

John Gilroy: Welcome to Constellations, the podcast from Kratos. My name is John Gilroy and I'll be your moderator. We are recording today from the SmallSat conference in lovely downtown Logan, Utah. Our guest is Al Tadros, Chief Technology Officer at Redwire. We are here to talk about artificial intelligence and how it enhances SDA, or space domain awareness. We picked Al because he has real intelligence, not artificial intelligence.

Al Tadros: I hope so. I hope some real intelligence.

John Gilroy: Oh, we know you, Al. You're well-known in the community here. Let's jump right in. So Al, where can artificial intelligence help regarding space domain awareness?

Al Tadros: Yeah. Well, first, thank you, John for having me on, and it's a great event here and a great venue for this discussion.

John Gilroy: It's exciting here, isn't it?

Al Tadros: It is. There's a lot of energy. We just talked about VLEO and we have cislunar activities and so forth. Artificial intelligence is actually a continuation of advanced algorithms for autonomy, quite frankly, for space vehicles. So my background is in guidance, navigation and control, GNC, where there are a lot of classical approaches for controlling satellites, robotics, autonomous vehicles, and they have some limitations, quite frankly, especially as you get to more complex missions.

So artificial intelligence has the promise of extending the performance and capability of control systems, machine vision, robotics across the domains, and we can deep dive into each one, but machine vision is all around us here on earth. Facial recognition, self-driving cars, even access, Clear access at TSA, at airports, and those kind of functions can be put into space. And that's one of the promises for space domain awareness is the ability to put machine vision in orbit, we're using AI algorithms.

John Gilroy: Okay. There's a popular data writer named Dave Linthicum. He's written a bunch of books. He's a smart guy, and he had an article last week, and I just love this quote. He said, "The reason you have stupid AIs is because you got stupid data." So artificial intelligence is essentially based on data from somewhere.

How do you address data provenance and how do you ensure the fidelity of the data used for AI?

Al Tadros: Right, right. And this is a common topic across AI. What was it trained on? When it hallucinates, how do you know?

John Gilroy: That's the word. That's the word.

Al Tadros: Yeah. Yeah. Same thing in space. There's no difference. The challenge in space is that you don't have the billions and trillions of data sets that you might have off of social media. We do have 50 years or 60 years of data collected from space, from platforms, and some people have access to some data. Not everybody has access to all the data. So you have to make do, and the algorithm performance is affected by that.

However, there is an area of research that is looking at, well, can you use simulated data? Can you actually create a data set to train on that is simulated, but good enough to get algorithms working in space? And that's some of the areas that we're looking at as well. There is on orbit data that we have access to, and there's also simulated data or model-based data that we're using.

John Gilroy: Yeah, yeah. Well, I got to use a phrase that's normally not used in these environments and the word is blockchain, okay? Quickly, can you explain blockchain technology and how it could be used to ensure the integrity and traceability of data shared among different entities?

Al Tadros: Yeah, very good point. Now, I'm not a blockchain expert. However, the information assurance, understanding where data came from and the chain of command of data sets that you're using, meaning who's interacted with it, who's modified it and so forth, is a task for something like blockchain where it can't be spoofed, it can't be hacked, and that is one of the applications of blockchain.

So there's an interesting confluence of different technologies that might enable higher confidence in algorithms that are produced. And then even beyond that, there is a long history of overlaying kind of supervisory fault detection, isolation and recovery. And I think that that's going to be an enhancement that improves the trustworthiness and the recovery from any kind of hallucinations from AI algorithms.

John Gilroy: Wow. What a nuanced answer. I think you should listen to this transcript. Boy, that was very well done. I mean, I heard a lot of people answer that, but that was... You hit all the right things the right way, Al. That was really nice. I enjoyed that.

Al Tadros: Well, thanks. I mean, there is-

John Gilroy: There's nuance to it.

Al Tadros: ... huge value and potential here. So the real engineering behind it is the trick, and I believe we're up to the task.

John Gilroy: Yeah, yeah, yeah. Well, let's go back to SDA. So you talked about different types of data and simulating data and emulating data. So what types of data are available for an AI model?

Al Tadros: Right. Well, the good thing is that we've had the space station up and operating for many, many years. And in fact, we've had high definition cameras on the outside of the space station operating and even visiting vehicles, cargo vehicles and crew vehicles coming in and out or being taped, astronauts walking around, equipment being moved around. That data set of imagery is some of what's out there. There's also commercial imagery, and I think some of the commercial land imaging companies have turned their cameras onto things like Hubble and Space Station and others. And we've collected what the vehicles look like in that.

We have a star tracker that we can use to identify non-stellar objects, objects that move relative to the star background, star field background. There's a collection of imagery that might be unresolved, meaning that it isn't a full image, but it is identified as a pixel or a set of pixels that is moving. So there's a whole slew of different images or data sets that we can use to try to train models, and it's exciting to see where those can take us, and then what do we have to do to go beyond that?

John Gilroy: That could be the title of your next documentary, Star Tracker.

Al Tadros: Star Tracker.

John Gilroy: Star Tracker.

Al Tadros: I like that. Good point.

John Gilroy: Your next documentary. How do we figure out where's where? Where's everything in space? Let's focus maybe a little bit on the Air Force here. So General Salzman, the Chief of Space Operations with the US Space Force, has talked about actionable awareness, which will be powered by various capabilities including artificial intelligence. So what kind of threats could AI help with?

Al Tadros: Right. This is really important. We don't want to just get resolved imagery. We don't want to just get pictures, and we don't want to just do RPO. We want to actually extract characterization and intent. And to do that, it takes an understanding of, well, how do satellites normally operate? Is it an anomalous operation or is it a very intentional operation that you're witnessing and is it a threat or is it benign?

So those kind of activities can be started to be extracted with a trained model, trained on what satellites look like, what satellites look like when they're commercial, what satellites might look like when they're very dynamic and operational, how they might approach you, the norms of behavior which are being stood up by different organizations like CONFERS. Is it within that or outside of that? Those kinds of things baked into a training model can start to help you say, "Okay, what is this object and what's its intent by approaching me and being in this orbit?"

John Gilroy: Advanced space domain awareness requires identifying patterns and anomalies in space, object behavior such as unexpected maneuvers or changes in orbit. So Al, are there tools to do this kind of advanced SDA even today?

Al Tadros: Well, there are, and there are some amazing companies doing from the ground using radar and telescopes, both amateur telescopes as well as professional telescopes. So there are, and you can see them announce when another country's satellites might be doing something that is noteworthy, like approaching another nation's satellite and so forth. So we do have some of that.

The challenge is we don't have all visibility, full sky visibility all the time, and as we start going to cislunar space, it becomes even harder. It's a bigger area to monitor further distance away, and you have the moon blocking your view for some of cislunar space. So all to say that the space is getting smaller in some ways, more access to space, more nations accessing space, and we're going deeper in space, meaning that going to cislunar and beyond is part of the interest now for SDA.

John Gilroy: Al, there's a popular documentary called *Wild Wild Space* and there's all kinds of numbers, and he talked about like 30,000 satellites by 2030. Everyone has a different number. It's going to be thousands and thousands. We know that. So could you further optimize satellite orbits using AI to reduce the risk of collisions and improve operational efficiency, or maybe how else could AI be used for this collision avoidance? There's going to be a bunch of them up there.

Al Tadros: Right. Right. Well, definitely for autonomous maneuvering, autonomous navigation, especially in a constellation where it isn't about where one satellite is, but where all the satellites are relative to each other, that kind of heavy compute is something that AI promises to advance. There's also the

autonomous operations aspect of it, not just future planning, but let's say you do have a conjunction identified, but it's at the edge of whether it's concerning or not concerning. AI could help advance the autonomy of deciding as it gets closer whether you maneuver or not.

I also want to take the opportunity to say that yes, we have thousands of man-made objects, human-made objects being launched. There's also something like 40 tons of natural micrometeorite debris entering Earth's atmosphere every day.

John Gilroy: Wow.

Al Tadros: This is something that's probably under-discussed, that it isn't just human-made objects, but we need to understand when a micrometeorite, a natural debris, impacts our satellites and the attribution around that. What is the characteristic of that? Is it clearly attributable to natural debris or is it attributable to human debris? Is it intentional or unintentional? Those kinds of things are part of what I think AI algorithms can start to suss out from the data.

John Gilroy: So currently, do we trust AI enough to engage in automated response systems that can react to detected anomalies? For example, could it be trusted for deploying countermeasures or adjusting orbits? Who do you trust, huh?

Al Tadros: Very good. In fact-

John Gilroy: Or what do you trust?

Al Tadros: Yeah, yeah. Well, I will say it's what and who. Even humans are non-deterministic. Someone was saying, "Well, AI is non-deterministic." And I was thinking, well, you take a set of humans and you put them in an operational sense, and depending on what's happened before, what's happened after, their mood, whether they had coffee or did they have a fight in the morning, they might behave differently in the same situation.

So we need to think about AI in a similar sense. AI is at best using the information that it has and making decisions we need to have a guardrail for, okay, what if that decision, although it's best intentioned with the best information, is still misguided? So that's where the supervisory level of fault detection, isolation and recovery comes in, something that stops you from doing something permanently harmful and helps you recover even with the best algorithms you have on the best data. And I think that that's, again, a continuation of the architectures that we have today with the understanding that you might not have a deterministic, a closed-form solution with the AI algorithms running.

John Gilroy: Well, here we are at SmallSat looking around all kinds of people, excitement, all kinds of new products and everything else. And I'll bet if I had a survey here, I bet the majority of the people here have read Ender's Game, you know?

Al Tadros: Yes.

John Gilroy: In case you haven't, this is a game that helps train space cadets. Do you think AI would be appropriate for SDA training? I mean, think about it. Could it set up random scenarios and support with insights based on real-time data analysis? It's almost like a test drive or a simulation. Is the technology here yet?

Al Tadros: Sure, absolutely. In fact, you've probably seen humanoids using AI, speaking to each other, and I know that a number of people are working on such facilities. We are actually already, we as an industry, are already looking at AI astronaut aids, someone that would interact, a vehicle or a robot that would interact with astronauts at the level of communication and responses that astronauts are used to in order to help solve problems, assist or just have emotional support or conversation.

So the answer is yes, there's an element of our industry that works on digital engineering, and we are already implementing digital ecosystem that would incorporate things like advanced algorithms and demonstrate them. And you can have the opposing, what if you have an AI identifying anomalies or threats and attacks operating against you?

So on both sides, I see the now readiness and availability of a digital engineering environment that can simulate a lot of this for training purposes, for ground system testing, for procedure checkouts. All of this can be done with AI enabled algorithms in digital engineering.

John Gilroy: I'm from the Washington DC area, and if you're at a barbecue, a popular topic might be encryption. There's all kind of all the places, but DC is where they talk about this. So let's talk about encryption here. So can you give us some insights on AI-based encryption and how that could relate to SDA and cybersecurity?

Al Tadros: Yeah. Well, first of all, again, I'm not an expert on quantum, but there's a lot of potential and people working diligently to advance our encryption capability using quantum computing. So I think that there is the promise of that to surpass anything else that we have done to date with regards to encryption.

I think that going back to even machine vision, AI algorithms for machine vision, that what used to be just facial recognition, you can start to use behaviors, gestures, facial gestures, micro gestures to start to encrypt not only who the person is, but is that consistent with their behavior. I think there's a variety of forms of encryption that we're going to be starting to see with regards to both

complex systems for autonomy, but also for access to data. So yeah, there's quite a bit there that AI is going to be involved in.

John Gilroy: Well, back to DC, there are certain three-letter agencies that aren't real fans of information sharing, but let's break it up here anyway. Is it possible to distribute AI systems for SDA that enable collaboration and information sharing among multiple stakeholders such as governments, international partners, and commercial industry? Do you know of a network that can do that or plan to place to implement that kind of vision? I mean, that's pretty brave.

Al Tadros: Yeah, very, very good point. And actually, this is a hot topic and hence an opportunity for businesses to place, let's say, an enterprise level AI system behind a firewall where it can operate securely and not expose the data that it was either trained on or it's collecting in the generative form.

So I think that that is an area that, I mean, right now, people are familiar with ChatGPT and all the others. I think there is siloed firewall AI algorithms that are going to become more and more common, and it will allow you to have that capability to both use proprietary, but also share with trusted allies.

John Gilroy: Well, you've really given us a great perspective on understanding artificial intelligence and SDA, and if you're listening to this, go to the transcript and print it out. There's so many nuggets of wisdom in here and puts things in perspective that a lot of my previous guests kind of gloss over. But this is really a fascinating interview. I would like to thank our guest, Al Tadros, Chief Technology Officer at Redwire Space.

Al Tadros: Thanks, John.