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Naira Hovakimyan

University of Illinois, Urbana-Champaign

IEEE RAS Interviews

Q1: Tell us about your family background and upbringing.

Naira Hovakimyan: My mom was a scientist. She had PhD in geography. And my dad actually served in military, and he was also an athlete. He was Armenia's champion in wrestling. So family-wise, I would say that from mother, I inherited maybe the curiosity that a scientist should have to always ask questions, to pursue intellectual innovations, and to be persistent. And our dad, due to his athletic background, he taught us two different forms of sports in childhood. Like he was playing chess with us since three years old. He was taking us for swimming, for tennis, for different types of activities. And as an athlete, he was always emphasizing how important it is to be competitive, and to win again. Even if you fail, you have to play again. And always to try to be the champion, like taking the second place is not good. You have to be the number one. So this athletic spirit that he kind of embedded into his kids, it's me and my sister. So we both strived to be successful in life, both academically, and also like career-wise. My sister is, for example, a very experienced ophthalmologist, very good surgeon, but she publishes books. She did two dissertations. And I think that scientific spirit comes from mom. I don't have any other involvement besides academia. My sister is just active surgeon and also publishing a lot. So that's how big is my family.

Q1: What were your life experiences prior to university that influenced your career?

Naira Hovakimyan: Sure, I went to a special school of English language. It was just called like that. Back in Armenia, that was then part of the former Soviet Union, with schools of different types, with schools for special math education, for special English, for special Russian, whatever. So I went to the school of special English, and that helped me to learn the language, since childhood, fluently. And we had very tough school in the sense of also physics and math teachers. So while in my younger days, like in elementary school, middle school, I was still thinking that maybe I would just go and become an English teacher or something, later I got attracted to math and physics. I went to university to study math and physics for my undergrad.

When I graduated from the university in 1988, that was in Armenia. I mean, that was the time when the former Soviet Union was collapsing, and things were getting very edgy. So I went to Moscow to get my PhD. It had more stability than Armenia. So I got my PhD, but then it all collapsed. And when it collapsed, actually the life in Armenia was very tough. We had no electricity energy for a few years. The salaries were equivalent to \$5 a month. So I started looking for opportunities to get scholarships in Europe. So first scholarship I got in Germany in 1994, and then I got another scholarship in France in 1997. Eventually in 1998, there was an opportunity to come to Georgia Tech to work on stability analysis of flight control systems. My degrees were in math. My PhD was in math. And the opportunity at Georgia Tech was attractive that I could explore some applications of math in the real world scenarios.

So I decided to take the risk and to move in new directions. So since then, my life moved more into asking fundamental questions in math that could impact real world applications.

Working five years at Georgia Tech, I learned about the system of values from the engineering perspective. And eventually that experience helped me to get, first of all, a faculty job in Virginia Tech, and also to be able to formulate questions that would matter to practitioners, and to come up with answers that would be acceptable by practitioners. To have a set of assumptions that can be owned by an application. I didn't have any education or training for that prior coming to the US. I learned how to collaborate with people across different disciplines, and I learned, I enjoyed, and I managed to grow. And that's what helps me today to lead a large lab with many students and work on different challenging problems.

Q1: Do you have any mentors?

Naira Hovakimyan: Absolutely. So first of all, my PhD advisor in Moscow, he taught me how to ask fundamental questions, how to define a problem on the level of foundational mathematics. While working at Georgia Tech, I had, of course, a post-documentary, Tony Kaliz, who helped me to understand and discern mathematics from the engineering perspective to see what value it brings. But also working at Georgia Tech, I met lots of collaborators from Boeing, like Kevin Wise, from NASA, like Irene Gregory. I met other professors and collaborators from government industry, like Belinda Bottom, who was the AFSR program manager by then, just showed me how AFSR would value fundamental work that would have practical value. So I worked with lots of people, and if I start talking and mentioning all the names, the list will never end. And I definitely give them the credit for guiding me towards the real-world problems.

Q1: Who was your Ph.D. advisor?

Naira Hovakimyan: He was Arik Melekian. Unfortunately, he died very young at the age of 64 in his office from heart attack, and he had huge influence on shaping my taste for mathematical problems.

Q1: Please tell us more about your work experience.

Naira Hovakimyan: So at Georgia Tech, I was in aerospace engineering, and that was the time when Georgia Tech was working on the X36 Thales unstable unmanned platform, trying to deploy adaptive control systems on it as an experiment, because adaptive control started in 1950s or '60s, and the first experiment was unsuccessful. In 1967, a pilot was killed, Michael Adams, that later it was found that the onboard adaptive control system went into saturation, leading to that fatal crash. And 30 years later, like the theory had developed, people were trying to deploy it again. But adaptive control had fundamental issues with transient performance bounds and stability aspects. It had a lack of robustness, if I could use a little bit terminology.

So the years of experience at Georgia Tech helped me to see the open problems, and when I started as a faculty in Virginia Tech, I was lucky to get a postdoc Chang-Yucao, who is now professor at University of Connecticut, who had similar interests to work in this area. And two of us together started working on L1 adaptive control theory that eventually was tested on sub-scale Boeing, and NASA Langley later it was also tested in Edwards Air Force Base on Learjet and CalSpan with people onboard, proving guaranteed performance bounds and robustness on manned aircraft. That was a huge achievement from the perspective of technology transfer. And we were lucky just to have these opportunities to work with so many people, earn their trust, so they could trust us, their vehicles, with people onboard.

Q1: What inspired your initial interest in robotics?

Naira Hovakimyan: So having this flight control technology that we were able to demonstrate for different adverse events, adversarial scenarios, eventually we got to a point when National Science Foundation started the National Robotics Initiative. It was a major program at National Science Foundation to boost robotics research across the country. Those were large grants, and we thought how could we apply for this funding opportunity using our success in control technology? Because robotics is multidisciplinary, just control is not enough. You need perception, you need computation, you need different disciplines to come together. And it was an interesting story. So one of my former collaborators from Naval Postgraduate School, Isaac Kaminer, had passion also for tango dancing.

One day, using one of my students who was by then also working in his lab, so he started with an exchange program in that lab, he decided to demo a tango of two drones, two drones tangoing, using some of cooperative path following problems. And my student was able to get a major award for that, Euro INAUDIBLE, whatever competition it was. And when he got that award, it came on UIUC website. When it came on UIUC website, one of our dance professors emailed us, saying, "How did you get these drones dance tango? It's so beautiful. Do you know that tango is the only dance where the artistic performance is achieved through cooperative sensing? If you put ten people on the stage to dance salsa, cha-cha-cha, or one of these other waltz, they will have the rhythm, they will always repeat the same. But tango, the same couple, morning, evening, will dance differently. Ten people on the stage will dance differently. Every time is different because the artistic performance is achieved by instantaneous cooperation between the two people. They feel each other, how they touch, how they sense. And our algorithms were meant for cooperative sensing. And she offered us to collaborate with her. There is this consilience project which was happening in Urbana Lincoln Square. The objective of it was that the dancers start moving without the music, with sensors attached to them. And principal component analysis software was producing the music based on their walk, walking movements. And that was passed to real musicians who were sitting there for five of them with a band and starting to play to these notes. So dancers were generating the music. And the offer was to use this music to get the drones dance with the people. We thought this is a super cool robotics project. It was so exciting.

We wrote this NSF proposal for National Robotics Initiative and we got feedback that it's super cool, but you have to show the benefits to the society. Because that's one of the NSF's premises. And we started already thinking how we can be useful for people. And the NSF manager gave an idea to do disability, elderly care, something like that. And we started working on how the drones could be used, for example, to deliver you a pill. Say, like in airports, when you have soap dispensers, you put your hand under it and the soap comes. Similarly, if you get elderly people at home who don't want to move to elderly facilities, they can have a drone from an iPhone, a small drone. From an iPhone, they can push a button. A pill could be delivered by a pill dispenser and brought to him because the elderly care industry is growing. As the younger population, is just not enough in quantity to help all the elderly. Because of the health care getting better, medicine getting better, people live longer. And the birth rates are going down. So we're going to face a huge gap when you just can't have enough elderly living facilities and young people helping them. People will prefer to age at home with the help of a few technologies.

And if you can set up, for example, their pills to be delivered, missing glasses to be found, like the drones have the agility, they can pick up a fork from the floor. But they have to be safe and friendly. So people's perception of safety differs from the actual safety. In engineering, you define safety like lack of collision. If you don't collide, you don't crash, you're safe. But people's perception of safety is different. It's one thing talking of drones flying outdoors, it's another thing talking of the drone bringing you medicine. You may be scared and run away. So people's perception of safety is a known phenomenon studied by psychology professors. And we got a collaboration with her for that NSF grant opportunity. And they taught us how they build these anxiety models by using galvanic skin response. And using this anxiety model, we could build path profile, velocity profile for the drones to fly around people so that they don't scare people and they can interact. That project got us into New York Times. And we got the NSF funding. Later, we had the Amazon Prime related NSF project again with a psychology professor on drone delivery. For last mile delivery, parcels, how to do path optimization, how to get efficiencies with the help of drones.

And today we have a lot more other interesting projects. So it all started from the dance, but we end up really serving the society, serving people. And today's projects that we have involve already more challenging problem setting. How, for example, to fly the drone in GPS denied environments where it will have to do search and rescue, for example, help people in emergency response after hurricanes, after tornadoes, or like work with farmers like what we do in our company, where we collect the data and we help build analytics. So there are different applications today that we work on.

Q1: What was the first robot you heard about?

Naira Hovakimyan: The first robot that I heard of, maybe it may go back to childhood sci-fi movies. And now I will have hard time to remember what would be the first movie that I've

seen or how far I should now think of my childhood memory. But the first real robot that kind of amazed me was maybe the vacuum cleaner, right? So that people can have robots like vacuum cleaners to clean their house. That's the simplest first, right? And then today there are so many different robots, like that are social companions, that are like starting from that same Alexa or the Siri on our iPhones. Like Siri on our iPhone is also considered the robotic technology. Robots that could operate in space, right, were talking about Mars Rover, having an unmanned helicopter on Mars. That's a robot, right? So the range of robotic technologies today is huge. It's huge. But my childhood robot, I can't remember what was it.

Q1: Tell us about the first robotics project your worked on.

Naira Hovakimyan: It was this dancing of the drones, if we call it the first robotic project, then this elderly care that we worked in our lab.

Q1: What year did the Dancing Drones project take place?

Naira Hovakimyan: Dancing drones goes back to 2012-2013. And then 2015, we got this elderly care drone project funded. Then we did some fun experiments here, like drones flying with LED lights, printing like "National Robotics Week" in the air. And so we did this fun project in Krannert, in Krannert Center here, which is not far. This is our center performing arts on campus. We had a big event where there were lots of people. I don't remember what exhibition expo it was. And we could give people the iPad. On the iPad they could write any sentence. And through Wi-Fi or internet, it was communicating to students in the lab. Not students in the lab, to the drones in the lab, but there were students watching for those. And these drones could fly with the lights and paint this sentence in the air. And these projects are all on YouTube and can be watched. So we did lots of these fun projects.

Q1: How did your background in mathematics lead you to robotics? (What was your career path?)

Naira Hovakimyan: I think the career path, philosophically, I would split into three segments. At first you work on discoveries, then you work on establishing yourself, then you work on serving the society. So robotics comes in the last stage of my life for serving the society. It wasn't on my path lifetime-wise. If I do the temporal scale of my life, when I was working on discovery, it was math. When I was working on self-establishment, it was maybe the big aerospace companies. And when I got to robotics, it was serving the society. That's how I would split a good career of everyone.

Q1: Are there particular fields of mathematics relevant to your work?

Naira Hovakimyan: So control optimization, path planning, networking, right. There have been lots of different disciplines that come together in a robotics application.

Q1: What are the main research questions you've been interested in?

Naira Hovakimyan: So The research questions that we were interested in, if I talk in the particular context of robotics, go back to these fundamental questions that we asked during our tenure at Virginia Tech, how to define, for example, adaptive control systems with robustness guarantees, that we were able to fly on sub-scale Boeing 757, on Learjet and on many other platforms. What we demonstrated there, that we could, for example, handle different types of adverse conditions without losing stability. We could hold the aircraft that's stalled and give the pilot the opportunity to recover the aircraft from crashing, if you know that it's stalled. And then the question came up, could we use these technologies in robotics? And that question came up, actually, I have to give the credit to Evangelos Theodorou from Georgia Tech. I was visiting Georgia Tech in, and he showed me a drone racing environment, a simulated environment, that was created for people to compete with their algorithm, who would be the champion of the drone racing. They were not the champion, but they were one of the finalists, and he asked me if we could bring our control solution to improve their, over their architectures, over their performance.

And it was clear that what we have done and demonstrated on Learjet, on F-16, would not be applicable to that, because the drone racing environment was a highly cluttered, uncertain environment, like an environment that one would have post-hurricane, post-tornado. And to fly there, you need continuous updates on your flight path, continuous learning. It's a data-driven environment. It's not like the open space where the Learjet or F-16 or Boeing airplanes are flying up in the air, where the path is defined a priori. You come to a cluttered environment, especially uncertain environment, post-disaster. The path has to be learned on the go and updated in this data-rich environment.

For that situation, we had to update our algorithm and to come up with so-called distributionally robust frameworks. And over the last five, six years, we have been working on extending our work to this distributionally robust framework, where we could bring it to robotics environments, where we could continuously update the models based on the data learned, and at the same time have our controller work with it and speak the same language. These are the last discoveries of our work that keeps us excited and going on.

Q1: were there any tools that opened up new possibilities in your research?

Naira Hovakimyan: I mean, these large language models are just one year old. Let's agree. And we are influenced by that. Right now, what we're trying to do, when I said we had this drone for

elderly care, like socially aware drone, we built social awareness for the drone in terms of path planning, interacting with humans and so on. Now we're trying to do a little bit of the inverse task. So the human starts teaching the robot using large language models. So they're starting to influence our work. We still don't have results, papers or funding in that direction, but we're writing a proposal that hopefully it will get funded and then we can have humans teaching the drones to make them customizable. Because it's one thing you produce something, it's scalable. And when the robot reaches the person, you want it to be customizable, teachable. So we want the person, every person to be able to teach the robot to do the things the way the person would like. And the person would feel comfortable because we are all different. So we're working on it. And here is where the large language models are having their influence. And we're trying to write a few proposals to get funding to do that work.

Q1: Have new technologies influenced your work recently?

Naira Hovakimyan: So The way the industry evolves, right, there are better and better drones coming out. Like last year, we acquired a few drones. I forgot the company, but you'll take the picture in the lab. It's called a Rog-X drone. Rog-X drone. I don't remember the name of the company. It comes with already onboard autopilot to navigate in GPS-denied environment with a full autonomy stack. So the industry evolves and they produce better and better systems with fully integrated sensors and gives you the opportunity to move much faster in your research. So I have to give credit to the rapidly growing industry. But as far as robotics is concerned, you ask me, I will say the best is yet to come.

Q1: Who has funded your research and how have you developed those relationships?

Naira Hovakimyan: A very good question. So my work has been funded by Air Force Office of Scientific Research, NASA and National Science Foundation. Most of the funding came from these three federal government agencies. I also occasionally had funding from Army Research Office, Office of Naval Research, some companies. But the key major weight of the funding goes to obviously NASA, INAUDIBLE and NSF. Relationships. So with NSF, it's always a little bit like gambling. You just write a proposal and submit. But with NASA and Air Force, we have developed relationships in a very systematic way. So we are continuously funded by the same people, the same groups, the same divisions. And it has worked because we have continuously worked in parallel on technology transfer. We did experiments at Air Force Base, Edwards Air Force Base in California on Learjet and F-16, putting our controllers on their real vehicles flying. Lockheed Martin is today, using Air Force Academy vehicles to flight test our controllers. NASA is using it on a bunch of vehicles on their base. So there is this synergy of efforts. There is this history of relationship that supports the work. And that's how they keep us funded.

Q1: Has funding influenced your robotics research?

Naira Hovakimyan: Absolutely. Absolutely. Yes. These people have guided me. They have told me what's acceptable for them, what's not acceptable. They have done adjustments, corrections. They have collaborated with us. Besides giving the funding, like with NASA Web Cooperative Research Agreement, we have NASA team with whom we meet biweekly. And we pass software to them, papers to them. They pass models to us. It's continuous exchange. And obviously, certainly we're influenced by them. We work with each other very closely.

Q1: Tell us about companies you've partnered with.

Naira Hovakimyan: So the very first company with whom I worked, it was Statoil in Norway. They got the seminar announcement of my talk from University California Santa Barbara. They had some alumni. And they emailed me offering a consulting opportunity to work on their drilling applications. You remember the spill in Mexican Gulf. So there are challenges with pressure regulation when you're pumping oil in this uncertain environment in sea ocean waves and different temperatures and so on. So Statoil invited us to do consulting for their drilling application. That was the way they were able to work with somebody in the US. They couldn't give grants at private company.

Then we worked with Raymarine on commercializing their evolution autopilot. The contract and model came in May. The product had to be out in September. We worked the whole summer to help them get the product out. And they got 30% jump in their sales. We worked with hydraulic pumps of Caterpillar. They also got our Controller. They funded the student here, I think, as far as I remember. And then the student went there and then they commercialized it. Today we work with Lockheed Martin that's using our controllers on Air Force Academy vehicles. It's a part of big NASA University Leadership Initiative, a six million dollar award where we work with two companies, Lockheed Martin and Sierra Nevada Corporation. And Lockheed Martin is in charge of flight testing some of the methodologies coming from this NASA award. They are our subcontractors. So that's how we move forward with all these different companies. They all come with different interests. Even Seagate had interest in our control technology. And Seagate funded a student here for four years and the student went to work with them.

Q1: Is there an interesting robotics project that you've yet to pursue?

Naira Hovakimyan: You know, I have a dream. I say my to-do list for retirement keeps growing and I keep pushing the retirement age further. I have a dream to write good textbooks. I have two books now. But I have a dream really to write a good textbook, you know, with good examples. I have good lecture notes that I've developed over the years. They are very well polished. But these lecture notes still lack lots of connection with real world applications. And building up these real world applications and showing the real application path for these lecture

notes. I have a dream to write a few good textbooks. And I always say when I retire I'll get to it to convert my lecture notes into good textbooks. And on the other hand, I feel like I don't want yet to retire. This work gets more and more exciting, more and more interesting.

I have a dream to write a book on benchmarks. There are benchmarks in different disciplines, physics, maths, and different types of scientific directions, call it like that. At one point I was collecting all these benchmarks that one day to convert into a book, then I stopped collecting them because I guess these days you can Google and find everything you want. But a good book on benchmarks because benchmarks teach a lot. I have a dream to write a book on lessons learned through my life, something that would be autobiography. You know, but it's so hard. Life is not that long. I won't be able to write all these books. I think they will remain as dreams.

Q1: What is your most important contribution to robotics?

Naira Hovakimyan: I think our recent work that we're doing on distribution of the robust adaptive control, it has not been yet published, but I am already giving presentations on it. It will soon be available in open source platforms like archive.org. I think it will make significant contributions to robotics in terms of giving predictable certificates for learning enabled controllers. Like say take chat GPT. You can ask any question. It will give you an answer. You don't know it's correct or wrong, right? You still have to check. It produces papers under my name that I have not written, but maybe its algorithms say that I could have written this paper with this Berkeley Professor with this title. So it does approximations, interpolations, extrapolations. So that's lack of certificate it's called. What we do for robotics, we can produce certificates for learning enabled algorithms that we know that with this probability, this thing will happen or this is how it should happen. I think this work that we are now doing is going to be breakthrough in robotics, but it still has to be published, made available because we're spending like two, three years on deriving very fine results. And once it's out, the reality should be different. I'm optimistic.

Q1: How has robotics changed over the years, and what do you foresee in 10-20 years?

Naira Hovakimyan: Robotics has changed drastically but, it's now leaving its exponential growth. And it has to do with availability of data, cheap computation, sensors, satellite data becoming character resolution so you can do data fusion on different skills and it powers up robotics. But, as I said, the best is yet to come. I see the major challenges or major breakthroughs getting this personalized robotic assistance for people so you become comfortable to live with them. It's one thing to have Alexa at home or a companion robot. It's another thing to have a moving robot at house that you would feel very comfortable with. I think robotics will be very important for space exploration as we saw with Mars helicopters and many others. This will be critically important because space exploration is going to become more and more

important over the years. I don't want to talk of self driving cars or drones. This is already reality.

The other day I saw one of our professors posting on Facebook how the Uber car came without a driver already. So this is already reality and it's going to expand more and more. I think the miniaturization, the sophistication, the ease is for people to interact, people being able to teach robots and things like that becoming really part of your family, living with them. Certainly the battery technology is going to be critical in this point, like we see with a Tesla car or something, the battery degradation is happening unfortunately much quicker than what one would have liked. So that's how I see the field evolving. In the next ten, twenty years there will be more of all of these that I just mentioned. More self-driving cars, more drones, more personalized robotics. Everything is just now going through rapid development.

Q1: Has the effect of robotics in real-world situations surprised you?

Naira Hovakimyan: No, the effect has not been surprising because we did the theory aiming for that we were able to deliver. But for example, certain things like Raymarine reporting us that by changing their autopilots to work with our controllers, that's 30% market jump. Such a number I'm taking as FYI. I don't know if it's good or bad. Business people say it's good if they change software and they could get 30% jump in sales. That's a huge number. But on the other hand, I don't know. Maybe as a scientist I would have expected 100% jump or so. I don't even know how to compare and evaluate thing like that. But the fact that we could improve efficiency, safety, performance, and in every case it can be different. In every case, it can be different because these characteristics that we can achieve with our algorithm have to be performed and embedded in hardware, and the hardware has to serve the purpose, and this experience of working with different hardware, different industries of different culture also matters a lot.

For example, why did we have significant influence in aerospace industry? I have to give the credit to the flight simulators that have long history of being developed, being very mature. We can go through flight simulator, do the testing, get an idea of what we're talking about, and then go to the real airplane. When I was working, for example, with Stadt Leiter, also Schlombe, Berzeu, it was clear that other industries do not have the maturity of aerospace industry in that sense. They don't have their flight simulators running side-by-side. Today people talk a lot of digital twins and similar technologies that are the modern way of talking of flight simulators. Everybody wants to have a digital twin that can help them to test, validate different algorithms. So that's how much I can say that it is going to be different in every case. Scaling is not that trivial.

Q1: What are some challenges you have faced in your career?

Naira Hovakimyan: Certainly, there were huge biases from the community, control community where we started our work and the control community was not receptive to our work. We're

dealing a little bit with old boys network and facing challenges that I wouldn't even say that until now we have come to peace with them. Put it this way: I won't use names, obviously however, these challenges didn't stop us from moving forward because nobody pointed to mistakes. There was a resistance towards publishing our work, but if a mistake is not found then the world goes on. You find other venues to publish and today with internet and archive.org and lots of other opportunities, we could get our word out. It's just a lot of hard work. Then technical challenges. I'm happy, fortunate, lucky to say that I had talented postdocs, like starting from Chenyut Sao, from University of Connecticut who is now professor there. He was an MIT graduate, of course. Today I have Aditya Galawa who has extended that network to distributionally robust frameworks. I had a number of talented postdocs on my way who were happy, excited to put a few years of their life into discovering the new frontier of our research that would keep us competitive, that could keep us moving without standing, and waiting for more biased comments or I don't know what. So there was huge opposition. That opposition is still alive, but we're making progress. The rest is history.

Patience, you have to have resilience, and you have to sit and do these experiments, testing, testing, testing. This is a field where the experiments should not be underscored, undermined. You have to do as many experiments as you can. You have to stress the system. You have to understand the failure cases, scenarios, safety margins. And it's very important that resilience to be with you all the time without giving up, right? We're not talking about Alexa robot, or Siri robot. That's just conversation. We're talking about self-driving cars, drones, personalized robots that could be around to help you. And they require lots of careful planning, testing and development. There should be no shortcuts in development of robotics applications. That's what I tell my students, that if you want to be in science, you want to innovate, you want to have impact. Don't take shortcuts even if you see the shortcut, don't take. This is not about taking one exit sooner or later on a highway. This every step has to be executed, checked, tested to have reliable, safe products by the end.

Q1: Are there questions we haven't asked that you'd like to add?

Naira Hovakimyan: Of course there are questions you haven't asked: How many students have you graduated? How many books have you written? How many papers have you published? There are questions like that that you haven't asked. Where are my students working today, right? The students that graduated? I have graduated - so, if you're interested, I have graduated already 26 PhD students. Six of them are in Apple. Three in Amazon, two in Google, Waymo, five in NASA, someone went to academia. I'm just talking about the PhD students. Also Boeing, INAUDIBLE, and all these other companies hired my students. I've published over 500 paper, written two books, and given tons of seminars and talks around the world. It's through education of students that the work goes on and leaves. Because once they're out, they're in different industries, they implement our work in one way or another. It doesn't have to be identical because the scenarios matter. People in NASA start supporting our work so there is this payback form of mode when they work in teams at NASA that support our work.

There are a lots of new students coming, new postdocs, new directions, new excitements. The beauty academia is that, at any point, we can do anything we want. And that's how I use my tenure. This is the place to take the maximum risks, not to be afraid to crash, to fail, to learn, to grow. If we're in industry, then we're driven by quarterly revenues, KPIs of the industry, the risks have to be balanced, minimize, and son on. Here I am at a place where I can take all the risks, think outside the box, crash, fail, learn, grow. And I am living that life. I always tell my student, "If we don't take the risks here, who should take it and where?" That's how I view academia as a cradle, a place where the risks have to be taken. The risks have to be taken to learn to grow and that's how I live.