Transcript of "Karthik Mukkavilli, Machine Learning Project Scientist in the U.S. Department of Energy's Exascale Initiative at the University of California"

Clear Skies Ahead: Conversations about Careers in Meteorology and Beyond

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Kelly Savoie:

Welcome to the American Meteorological Society's podcast series on careers in the atmospheric and related sciences. I'm Kelly Savoie and I'm here with Rex Horner and we'll be your hosts. Our podcast series will give you the opportunity to step into the shoes of an expert working in weather, water and climate sciences.

Rex Horner:

We're excited to introduce today's guest, Karthik Mukkavilli, a machine learning project scientist at the University of California, working on the U.S. Department of Energy's Exascale Initiative. Welcome, Karthik. Thanks so much for joining us.

Karthik Mukkavilli:

Thank you.

Kelly:

Karthik, could you tell us a little bit about what sparked your interest in science and how it influenced your educational path?

Karthik:

Yeah, sure. So I was actually born in India and I lived there until the age of 12. And after that, I moved to New Zealand, which is where I grew up and did most of my high schooling and undergrad education. So my initial formative years, there was a strong emphasis—at least in the Indian education system—on STEM. So just going through that system sparked early interest in it, but it was slightly away from my true passions. And when I moved to New Zealand, I went through the motions of just going through high school and I excelled at math and physics and chemistry, those sorts of fields, but really, I discovered my real interest even after my undergrad in electrical and computer engineering and even beyond my master's. So at the end of my master's, I went to Imperial College of London for my master's in U.K., from New Zealand.

Karthik:

And I had a lot of opportunities available to me just having done two degrees in engineering and I started questioning, "What am I truly passionate about?" So I went back, in fact, to India at that point to figure out how I can perhaps contribute to society and just to get in touch with my roots. And I realized that some of the major issues that we were facing can't really be fixed necessarily with the engineering tools that we had already developed. And the focus had to shift to some of the fundamental issues like sustainability and climate change and just being in touch with nature. And I saw that technology was losing touch with what's happening out there in the real world, in the Indian context, but more generally

the rest of the world as we see now. So then I decided to delve a bit more into this and I started reflecting on initial experiences where I did have interest and certain topics.

Karthik:

And it turned out that during my undergrad years, as an electrical engineer, I did a final year project on solar energy in Pacific islands. And likewise, during my master's, I stuck with the whole solar energy world. And I ended up doing a PhD in solar energy forecasting and looking at the impacts of atmospheric aerosols in Australia. And initially I never had any goal of being a researcher or getting a PhD at all. I just wanted to do work in this area. So I started working with CSIRO, which is the Commonwealth Scientific and Industrial Research Organization in Australia. And I realized that, well, if I'm going to be in research, maybe I need to get a PhD.

Rex:

Tell us more about that first job you had outside of your schooling and how that led to where you've taken yourself to now in your career.

Karthik:

So my very first job was actually a software engineering internship during my undergrad itself. And that particular skill that I had developed relatively early became useful over time because currently what I'm doing is applying computational methods and artificial intelligence and machine learning techniques to solve problems in climate change and system science. So my very first role was actually in a bioinformatics company in New Zealand called Orion Health but through subsequent experiences and different engineering roles and through research, I decided to develop that particular skill set of mine, which is mostly around modeling and programming.

Kelly:

So you mentioned that you have degrees in engineering. So if a student was just starting school and they really wanted to pursue a job in artificial intelligence and machine learning, what degrees, courses, or skills would be the most helpful?

Karthik:

Yeah. So machine learning is a fairly diverse field and you do get people from different backgrounds but a lot of the latest developments and just to contribute to moving that field forward, having strong skills in applied mathematics statistics and programming is very useful to be a machine learning scientist. And there's people from operations research, those sorts of fields as well, who can come into this. And my background itself was an electrical and computer engineering. So that was my degree but yeah, so those would be the main skillsets.

Kelly:

What program languages are the most used now?

Karthik:

So I guess Python is a very useful language to learn just because it's very functional and relatively easy to pick up. And there's a lot of machine learning libraries linked with Python and the AMS conferences, in fact, have several Python special workshops and tutorials. And I think even certain sessions which are

focused on Python these days. So it's a very useful skill set as a meteorologist to learn because a lot of the work that's getting ported from Fortran to Python in order to interface with the machine learning libraries. And especially if you're going to be doing deep planning, so there's packages like TensorFlow and so forth, which you can link relatively easily through Python too.

Rex:

Tell us, Karthik, what position do you hold now?

Karthik:

I recently started a new role with the University of California as a project scientist, focusing on machine learning and systems sciences on the U.S. Department of Energy's Exascale Computing Initiative. And the goal of the Exascale Computing Initiative is essentially to get to the point where you can run a scientific computation at a billion instructions per second at that scale. So this is going to be really transformative to solve a lot of the problems that we encounter across all fields of science, but especially within a system science where we operate at various scales all the way from the macro to the minuscule or micro scales, it's very powerful to have access to such exascale computing systems.

Karthik:

And currently as we get more and more data coming in, we're living in this world of big data, which lends itself to the machine learning model as there's a natural mix between both the machine learning field work and the advances which are happening and increased computation. So this is going to have direct benefits to find scale prediction of extreme events like wildfires to flooding. Right now, we can't really predict this for households or make projections that accurately. So exascale computing would hopefully strike that sheet.

Rex:

So what's a typical day like achieving the goals of the Exascale Initiative?

Karthik:

So my typical day is composed of reading different research papers, understanding what's the latest set of algorithms both within—well, mainly within—the machine learning field and seeing how they can be applied to some complex problems, which the system science or meteorology and climate fields are facing. And yeah, programming and developing new algorithms, testing them, having meetings with different collaborators across the world but especially within your own research group. So over time it becomes a very close knit community. So having that day-to-day interaction through emails through just these days with COVID, Zoom meetings, and also attending conferences. Yeah. Relatively often is something my day would look like.

Rex:

How do you find the reading material that you keep up with?

Karthik:

Yeah, so I read pretty broadly all the way from just a general newsfeed that you would get from *National Geographic* or *Scientific American* or *Nature* news alerts, all the way to specific journal articles. I tend to be more problem-solving oriented. So if I'm faced with a certain problem, then I tend to do a Google

Scholar search of different articles, which perhaps focus on a specific question that I'm trying to answer. And then I do my reading along those lines, typically just reading the initial abstract and conclusions and the figures. And then if it's interesting, then delving more into the details of a specific paper.

Rex:

Are there any journals or news sources that you feel have a focus on the interaction of AI with environmental science?

Karthik:

Yeah. So actually this is a two-fold answer to this. On the one hand, this is a very new and emerging field. So there isn't currently a proper interdisciplinary journal in this field. And in fact, I've been invited to serve as an editor at one of these, I don't want to publicly name it yet until it's official, but there is the idea of creating such a journal at the moment. But so far, most of this super interdisciplinary work, which is broad-reaching, gets published basically in *Science* and *Nature*, but at the same time, the barrier there is relatively high. So one of the issues is that there isn't a proper venue to publish this work at the moment.

Karthik:

In the AI conferences, more recently, there's been just since last year almost . . . I've been part of different workshop organizing committees and sharing certain workshops where we accept different papers, which are at the intersection of both fields, the AMS, AI committee, something I've been part of ever since, I think my first or that was the end of my first year of PhD. It's now existed for, I think maybe more than 20 years, they have an annual conference, which focuses specifically on these topics. But this is more on the conference space and less than the general space.

Kelly:

So what do you like most about your job so far?

Karthik:

What I like about my job the most is that it's so close to real-world impact most of the time. I think that's difficult to get from a lot of other fields while you can be a machine learning scientist, even at some of the best tech companies. Most of it could be increasing ad revenue or better tuning, marketing algorithms. It's not so much about actually solving global challenges for the most part. So what I do with machine learning is hopefully for the social good and to solve important problems. So that's something which I find quite rewarding

Rex:

On the flip side, what would be the most challenging aspect about the work you do?

Karthik:

One of the most challenging aspects of the work I do is that after a certain point it requires you to delve super deeply and do parallel fields. And that can be hard to do for a certain individual because you need to be really, both a domain expert in a certain area but at the same time have deep knowledge also of the cutting edge work, which is happening in machine learning. So I do find that challenging but at the same time, yeah, mostly through coincidence almost I over time ended up developing skills in both

these fields because my undergrad was in electrical and computer engineering but then the PhD work was more in atmospheric physics and renewable energy forecasting.

Karthik:

So a lot of people who do end up at the intersection of these fields, they didn't quite plan it, I would say, it just so happened that their interested evolved over time to lead them to this. However, increasingly we're seeing very close links being drawn between both these fields and for people who are starting out now, I think they'll see closer theoretical connections at the interface of both fields. So a new set of qualifications and a new set of programs will emerge, I think, in the coming years where they can directly train at the intersection of both the fields.

Kelly:

So as far as your work schedule goes, does it allow for a good work-life balance? Is it a Monday through Friday type deal? Or do you have to ever work weekends or nights or anything like that?

Karthik:

So my work schedule is really flexible. So yeah, it's more like, say there's a conference deadline coming up or a certain ground proposal deadline coming up. I tend to work towards that. But in research its mostly how productive do you personally want to be as a researcher? So you can work 24/7 if you really wanted to or you can reduce that workload to what is feasible for you. Yeah. So there's a huge variance in research productivity across individuals but it's more to do with personal alignment of goals and even different researchers focused on various things. Some people like to focus more on the teaching side than in research because for them that's more rewarding. Some people try to focus more on technology transfer too. So that's another aspect it's very flexible and really up to you, how you want to evolve your career while you're in research.

Kelly:

Yeah. It definitely sounds flexible. So are there any benchmarks that you have to meet? When you have a review with your supervisor, do they look to see if you've written or published in a certain number of papers or presented a certain number of conferences? How does that work in terms of accountability?

Karthik:

Yeah. So certainly once people are trying to secure tenure at different departments, then it does get quite competitive. So they are reviewed purely based on how many, for the most part, based on how much funding they have attracted, how many high impact journals they're published in for them to move up the ladder. So, yeah, there's this mentality of publish or perish, which does happen. I am in a slightly different role in that I am currently not in the tenure track race yet. I'm more in the scientist role as opposed to in a tenure track role. So I don't have the same metrics as such, but in saying that, generally it hasn't been an issue, getting those publications out. So yeah, it's important to be very collaborative and that generally helps as well.

Rex:

You mentioned that a lot of the jobs in machine learning for some companies can be focused on more business goals, such as advertising or increasing profit in some way. Do you see the future of the job market changing? Do you see the intersection of AI in the environment? Are those jobs maybe driven by government funding or what does the future look like?

Karthik:

Yeah. So within the machine learning field, there is certainly a lot of time devoted towards problems which aren't necessarily focused towards the wider social good but that's a more fundamental problem of corporations and their existence at this point in time. So aligning shareholder interests with public interests, this is a basic problem facing the world at the moment. But putting that aside, I think AI has a lot of potential to benefit humanity. And there are a lot of companies working in this space too, which are doing amazing work to solve very critical problems, even within and perhaps even, especially within the earth sciences field. So you can have companies which are mining different satellite data to improve food productivity. You can have startups which are providing better extreme weather and climate forecasts. All of these applications we're seeing them come about.

Karthik:

So far, it also has been a case of just the technology not being mature enough for it to serve humanity yet. The reason why we haven't quite seen it, even before COVID, kind of strike the world, having a lot of mature machine learning technologies being deployed is because the technology hasn't really been tested to solve such problems yet. But through this COVID crisis, a lot of people are also working at the interface of machine learning and what's happening in environmental epidemiology and coming up with new commodities so that if and when the next pandemic hits us, there'll be a lot of tools out there to help the world.

Karthik:

And likewise, there is work happening within the earth science field. One of the issues has been there hasn't been, until very recently, access to large data sets from a very high resolution, say satellite data or other sensor data, which has been available. But now we are reaching a point where you can actually do something useful with machine learning too. So it's a multiplicity of factors. And at the same time as we're facing more and more crises, I think people are getting more cognizant of what's happening around them and what is important and what's not. So that's changing the nature hopefully, of the business.

Kelly:

So you started off with degrees in engineering and then ended up with atmospheric sciences as your PhD. Is there anything you wish you had done differently in your career or do you think the path that you started and ended up with is the best path for you?

Karthik:

Oh, no. I don't think I necessarily took the most efficient or best path for what I am doing. I certainly wouldn't call it a waste of time in any way, because it did inform me of what I was interested in and what I wasn't interested in. But if I were to redo it perhaps where I sit, I would probably have focused more on, perhaps as an undergrad, done applied math and statistics as a base. And then try and during the PhD perhaps focus more directly on just either machine learning or mathematical physics of some sort and then gotten into the area that I'm doing because that particular base is harder to acquire slightly later on. But in saying that what I've done allows me the ability to branch across and do things which could be even at the intersection of say robotics and UABs and wildfire prediction. So those sort of things, I have a greater appreciation of it. So yeah, it's hard to connect the dots looking forward but that's more a case of hindsight.

Kelly:

Right? I mean, you're definitely well rounded. And I would think that your skills would make you very marketable because you have a variety of specialties. So like you said, you don't really regret the path that you took because it's been an advantage but I do see how you would maybe want to take some different courses depending on where you want it to end up with applied math and statistics.

Karthik:

Yeah. So one reason not to do too many different things is just due to the way academic research is structured in terms of the hiring. So people who stick necessarily with one field and then build only through that, a lot of the hiring is still very disciplinary as opposed to being interdisciplinary. Although a lot of good research happens to be interdisciplinary. So it's a little paradoxical the way it works, mainly because yeah, it's just academia and different universities. And that the way they're structured are also outdated but there have also been sort of good reasons as to why that is the case. Over time, people have realized that specializing in certain fields is really the only way to progress with all the new scientific advancements at the pace at which they're moving in the modern scientific world. Whereas in the past, it was considered more important to be a polymorph almost but that's no longer feasible.

Karthik:

So I would say having focus is useful in many ways, but at the same time, it's important to have a broader perspective it's hard to achieve but it's a trade-off that one would have to make their carrier.

Rex:

Karthik, do you think there was a most exciting moment in your career you could pinpoint?

Karthik:

I think it towards the end of my PhD, when I realized that I had developed skills in a certain area like atmospheric science and I saw the developments which are coming about in machine learning, I realized that my previous background could also be useful again. So I did postdoctoral work in Canada with a Turing laureate, essentially that's like the Nobel prize for computer science. And my advisor, had received that after I actually began working with him. So that was a big privilege to work with him. And yeah, I've had the opportunity to work with IBCC, Nobel laureates but also people at the very best in the computer science field. So just having that sort of exposure has been very rewarding.

Kelly:

Are there any other opportunities that you would advise students to pursue if they were looking for a career in machine learning? Were there any things that you had done, internships or courses you took outside of university that were helpful?

Karthik:

Yeah, certainly internships are very helpful. I would say more than courses just a lot of—yeah, I'm of the opinion that you shouldn't really pay for studying this day and age—a lot of the work is available online. So don't be spending too much on education. Work towards a scholarship, if not self-learn is the new mantra I would follow. In terms of outside of academic research, there's a lot of really cool research happening in industrial labs, which is as cutting edge, if not more. So I wouldn't, even if someone wants to say, become a professor in the future, it's worthwhile spending time in technology company research

labs too equally, especially within the machine learning world. In fact, that particular flexibility doesn't exist as much perhaps say in meteorology. Although in meteorology people do end up spending time and national and government research labs, they don't have that same luxury of working in industrial and technology company settings.

Karthik:

And then again, moving across or back to academia. So if someone's working at ML, those opportunities exist.

Rex:

Karthik, before we let you go, we always love to ask our guests one fun question at the end of each of our podcasts. And I'd love to ask you if you could meet one famous person alive or dead, who would it be?

Karthik:

I would like to meet Isaac Newton, I think because I recently read somewhere that—just as we have with COVID—during the plague, he was super productive and ended up creating some of his most amazing work, just sitting at home. So I'd like to know how he ended up doing that.

Rex:

So some tips?

Karthik:

Yeah.

Kelly:

Tips that would help you out right now so that you can create some wonderful discoveries.

Karthik:

Yeah.

Kelly:

Well, thanks so much for joining us, Karthik and sharing your work experiences with us.

Karthik:

Thank you so much.

Kelly:

Well, that's our show for today. Please join us next time. Rain or shine.