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Artificial-intelligence researchers are finding ways to try out and to combine academic and industry work.

ARTIFICIAL INTELLIGENCE

A field in flux

Can researchers find a balance between academia and industry?

Artificial-intelligence (AI) researchers across all academic career stages are feeling the lure of industry, thanks to higher salaries and perks such as access to large data sets and computing resources. Businesses are recruiting AI specialists for projects ranging from modelling risk in finance to designing crop-harvesting robots.

In the past year, the number of PhD graduates on LinkedIn who say they have AI expertise has risen by 66%, according to a report published in April by the software provider Element AI in Montreal, Canada. And the number of researchers publishing at top machine-learning conferences increased by 19% (see go.nature.com/22nexux). From a sample of 4,500 researchers, the report authors found that the United States continues to be a major

hub of AI training and employment. Other hotspots include China, the United Kingdom and Germany. But demand is outstripping supply, says Yoan Mantha, market-intelligence lead at Element AI. The company estimates that in the United States, there are around 144,000 AI-related job openings and only about 26,000 developers and specialists seeking work.

The hiring frenzy is affecting recruitment of AI faculty members. In a March survey of 111 AI researchers and university administrators by *Times Higher Education* and Microsoft, 89% said that it was “difficult” or “very difficult” to hire and retain AI experts (see go.nature.com/2xe9fpk).

In a 2018 study, computer scientist Craig Wills at Worcester Polytechnic Institute in Massachusetts analysed advertisements for

tenure-track computer-science faculty positions with start dates in 2019 at 409 institutions, mainly in the United States (C. E. Wills *Comput. Res. News* **31** (1); 2019). Since 2015, the percentage of ads seeking specialists in AI, data mining and machine learning roughly doubled, he reports. And in a study of 176 institutions published earlier that year, Wills found that 42% of searches for computer-science faculty members by top US graduate schools failed to yield the desired number of new hires (C. E. Wills *Comput. Res. News* **30** (7); 2018). However, AI-related searches seemed to fare no worse than other subfields.

How are these forces reshaping the career paths of junior researchers, and what do they mean for the health of the field? *Nature* asked six AI experts to share their views. ►

GIREEJA RANADE

Industry perks

AI researcher at the University of California, Berkeley.

After getting my PhD in electrical engineering and computer sciences at the University of California, Berkeley, I did a postdoc and then worked as a full-time researcher at Microsoft Research in Redmond, Washington. I loved the idea that it would be different from an academic postdoc and give me exposure to real problems. It makes you more aware of the issues that product teams face; it helps you see the real challenges.

For example, I collaborated with people who were flying unmanned aerial vehicles (UAVs). As an undergraduate, I worked with robots, but for my PhD, I only proved theorems. Talking to the UAV researchers made me think about other problems, such as concerns about the safety of systems. How do you know when a system is getting into a dangerous zone? Is the UAV going to crash into the ceiling or floor?

One of the most exciting projects I worked on was studying the spread and impact of fake news and misinformation. Microsoft Research collected Internet browsing logs with users' permission. We looked at website visitation patterns during the 2016 US presidential election. Social media had a huge role in spreading misinformation. But there was one category of online stories, labelled as fake news by fact-checkers and other organizations, that did not rely on social media. In one case, a news-aggregator website drove a lot of traffic to a misinformation site; in other cases, people might have been directed to those sites through e-mail (A. Fournery *et al.* *Proc. 2017 ACM Conf. Inform. Knowledge Manage.* 2071–2074; 2017). In academia, I would not have had access to these data.

Last year, I came back to Berkeley as an assistant teaching professor because I like the idea of training the next generation. I'm a better teacher now; I can connect real-world work to material that the students are learning.

ANIMA ANANDKUMAR

Fluid barriers

Co-director of decision, optimization and learning at the California Institute of Technology in Pasadena; director of machine-learning research at NVIDIA, a company in Santa Clara, California, that makes graphics processing units.

Many students who are finishing PhDs are stressed — they're confused about how to choose between career options, and they worry that they're making a mistake. But it's much more fluid these days. There's unprecedented openness between academia and industry: more collaboration, researchers moving back and forth, and people like me with dual roles.

In the past, there were fewer research labs in industry and it was harder to publish. Now, many companies have an open-publication policy, and that means you're participating in peer review and embedded in a research community. It's easy to go back to academia. It's certainly not held against a faculty candidate if they were in industry for a few years, as long as they continued to publish. In fact, industry experience is highly valued.

I hear second-hand that junior faculty members worry about senior colleagues getting hired away. They're asking who do I get mentorship from? My advice is to seek mentors outside the university. Visit industry labs and other institutions, give talks and spend time making connections.

Junior faculty members shouldn't choose a research topic just because it's the current hot

trend in industry. There are truly important fundamental problems to be solved. At the California Institute of Technology (Caltech), we have an initiative called AI4science, which asks how AI can have an impact on scientific discoveries. Can we develop algorithms for biology, chemistry, astronomy and materials science, for example? At the moment, it is Caltech-centred, but we invite many external researchers to give talks; interested people can reach out to us.

There is a lot of media coverage of faculty members leaving for industry. But this is not a zero-sum game. It's important to have a healthy pipeline and give opportunities to a new crowd, especially from under-represented communities. Universities should be forward-thinking and ask themselves what kinds of people they can hire.

SAMEER MASKEY

The entrepreneur

Chief executive of the machine-learning company Fusemachines in New York; teaches AI courses at Columbia University in New York City.

I did my PhD at Columbia and then worked at the IBM Thomas J. Watson Research Center in Yorktown Heights, New York, on speech-to-speech translation systems. Even at IBM, it was fundamental research. Our performance was reviewed on the basis of publications, and we presented at conferences. There was a lot of creative freedom, but I didn't see us making a broad impact around the world.

I wanted to do something with a direct impact on more people's lives so I left IBM in 2012 and started my company Fusemachines. The mission is to democratize AI by making AI education accessible to underprivileged communities in developing countries and the United States. There are a lot of talented engineers who have completed undergraduate or master's degrees in these regions, but because they did not go to fancy universities, they might not get amazing work opportunities. They are good at programming but may not have a strong background in maths.

So we provide them with one year of free training in machine learning through online courses and on-site office hours. We have programmes in Nepal, the Dominican Republic, Rwanda, Burkina Faso and New York. Afterwards, some engineers work for us, or we connect them with companies, mainly in North America.

I'm also an adjunct associate professor at Columbia. I usually teach one or two classes per semester, on topics such as natural-language processing, deep learning, and AI in public policy. Education made a fundamental difference in my life; I grew up fairly poor in Nepal and got a full scholarship to come to



Anima Anandkumar divides her time between academia and industry.

college. So I've always been keen on education. When you see the light in your students' eyes as they learn something new, it's very satisfying.

To create a business, you need to convert research into product and product into business. That requires different skill sets. I've seen many engineers go down the rabbit hole of building something without thinking about the business model.

MAHSA MOHAGHEGH

After hours

AI researcher at Auckland University of Technology, New Zealand; founder and director of She#, a non-profit organization that encourages women's development and networking in the technology sector.

Almost every other week, I get approached by companies to have coffee or a chat. They want insights about how AI can have an impact on their field. They ask desperately whether I have any good students they can hire. Some ask me to join their advisory board. Next, they offer a contract to help them for a few hours a week. Later, they offer a job. One firm wanted me to become their chief AI officer. These offers are all very tempting — the salaries are so much bigger than in academia.

At my university, we can spend some of our time giving advice to industry and you can earn income from consulting. But teaching, administrative and research responsibilities don't really allow you that time. My time working with companies is mainly outside standard work hours.

Universities need to give faculty members more freedom to work closely with industry. When they look at track records of achievement, they shouldn't focus on publications. Industry collaboration should be the main focus, otherwise sooner or later they're going to lose staff (see "Top tips"). That's the only way you can keep people in a cutting-edge field in academia.

JILLES VREEKEN

Good and bad

Machine-learning researcher at the Helmholtz Center for Information Security and the Max Planck Institute for Informatics, Saarbrücken, Germany.

At the Max Planck Institute for Informatics, we've seen quite a few colleagues in non-tenured senior researcher positions jump ship to industry. These are often people on the threshold: they like research but don't mind having

TOP TIPS

Advice for AI researchers

Gireeja Ranade: Explore different parts of the field. Spending time in industry is a good way to gain broader exposure.

Anima Anandkumar: Keep an open mind, and realize that nothing's set in stone.

Sameer Maskey: If you have an entrepreneurial itch, think about the problem you're going to solve and how it creates value for target users.

Mahsa Mohaghegh: Develop connections with people at companies, even if you don't plan to enter industry right now.

Jilles Vreeken: Be ambitious. Apply for the job you can see yourself doing in a little while, rather than what you can easily do right now.

Herman Herman: Don't be afraid to take opportunities for more responsibility as they come. **R.K.**

more money, reasonable hours and much more choice in where to live.

I'm both very concerned and very happy. I'm happy for early-career researchers, because the academic system was and is pretty rotten.

In the past, many PhD graduates worked for four to ten years as postdocs, even though academia might not have been a realistic dream, given the competition for jobs. They were somewhat exploited and wasted years when they could have gotten valuable experience in industry.

After they finally quit academia, they often got an industry job with little or no focus on research. Now, they can stop hopping from contract to contract and get a research-oriented position at a company. For them, this is great.

For academia, it is really bad. A lot of research relies on these foot soldiers. There is a huge demand from industry for AI researchers, but we have not been training enough people. Who's going to teach students if the pool of faculty members dries up? Few people will need to shoulder the greater demand, and it's almost impossible to broaden the base because people get hired away quickly.

Many AI researchers can now choose between jobs that fit them, rather than being stuck in one that doesn't. Academic research is relatively solitary. In industry, you typically work in teams, which is more social and can make it easier to tackle bigger problems. Which resonates most with you? That's where you should go.

Employers' list of desired skills often doesn't make much sense — for instance, a request for ten years' experience with a framework that has existed for only two. So make sure you tick lots of the boxes, but don't feel inhibited if you don't tick every one.

HERMAN HERMAN

Step up

Director of the National Robotics Engineering Center at Carnegie Mellon University in Pittsburgh, Pennsylvania.

For junior faculty members who are putting together their own team, attracting top-notch postdocs and other researchers is always a problem. The key is to find people who want to pursue the same goals. A PhD graduate might get much better pay in industry, but they might be working on the best way to advertise products and convince people to buy more stuff.

So one way that junior faculty members can convince a researcher to join is to make it clear that they are working on something worthwhile. For example, one of our projects is developing robotic systems to clear landmines in Cambodia and Laos so that the land can be reused for farming and other purposes.

Another point that junior faculty members need to get across to candidates is that in small teams, you can make a bigger impact. Most academic projects are much smaller than in industry. Because resources are scarce, people are forced to be more creative. Sometimes it produces better research than if you work in an organization with a few thousand engineers.

When colleagues leave for industry, some junior faculty members ask themselves, "Should I leave too?" They need to think about pluses and minuses. In academia, you basically run a small company, in the sense that you carry out a wide gamut of activities; you have headaches such as getting funding, but you also have the freedom to execute your vision. In industry, you will make more money, but somebody might dictate what you work on. Don't panic and follow someone to a company just because you have 'FOMO' — fear of missing out.

When senior faculty members leave, sometimes it opens up an opportunity for junior researchers to step up and assume much more responsibility. For example, an assistant professor could become the co-principal investigator of a large team. Some people say, "Hey, am I ready for this?" There is too much second-guessing of their capabilities. I've seen junior faculty members take over research projects; fast-forward a few years, and they are very successful. ■

INTERVIEWS BY ROBERTA KWOK

These interviews have been edited for clarity and length.