Artificial Intelligence and Augmented Intelligence for Automated Investigations for Scientific Discovery

AI3SD Interview with Dr Nicholas Watson
29/01/2021
Online Interview

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Humans-of-AI3SD:Interview-9

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Interviewer	MP: Michelle Pauli - MichellePauli Ltd
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Figure 1: Dr Nicholas Watson

Dr Nicholas Watson: 'If you want to do things differently, you need people who think differently'

Dr Nicholas Watson is an Associate Professor of Chemical Engineering at the University of Nottingham and his research is focused on data-driven in-process sensing to deliver sustainable, safe and productive food manufacturing systems.

In this Humans of AI3SD interview he discusses the benefits of low-cost sensors for SMEs, why the real world is a lot more complicated than the controlled world of the lab, and the surprising value in getting your problems tackled by people who've never looked at it from your perspective.

3 Interview

MP: What's been your path to where you are today?

NW: I was always really interested in computers and modelling, so after my mechanical engineering undergrad at the University of Hull, I went to the University of Leeds and completed a PhD project in Chemical Engineering with AstraZeneca, looking at the monitoring of granulation processes – the processes that make tablets – using a technique called discrete element modelling and passive acoustic sensing. I was trying to understand how the particles moved around the equipment and how their properties changed as they did so. We were using the model to understand the sound generated during the process to develop an online monitoring system.

Throughout my PhD, I probably did two weeks of experiments, of actual granulations and recording the sounds at AstraZeneca. When it got to the end, I realised how much I enjoyed the experimental work in addition to the modelling.

At that point, I managed to get a short-term postdoc in food science that led to four years as a researcher in food science at the University of Leeds. It was a very strange postdoc because it was all short-term contracts, more or less for industry in the food, pharma, fast moving consumer goods space, all based on "Can you build a sensor to monitor this?" So we worked on the size of the bubbles in chocolate bars, crystallisation in car engines, stability of drugs, even stability for fake tans ... I ended up with orange hands for a couple of weeks with that project!

It was great work but it always followed the route of "Can you develop this and test it in the lab? If it works in the lab, we'll take it to the factory." As an engineer, I got frustrated because we tended to stop at the lab stage. Taking a working lab idea into a factory was really, really difficult: in the lab we can do things in a controlled environment and, if it doesn't quite work, we can do it again. Not so in the real world.

For one project, we did some work for a company that said, "Can you build a sensor to look at these particles in suspension?" So we did a simple experiment where we put some glass beads in water and sent an ultrasound wave through it. We did it and we could say, "Look, you can see a change in the signal, so you can monitor this process."

We went to their factory, put the sensor on the pipe and the signal was all over the place and I said, "Well, what's in the pipe? Is that glass beads in a fluid?" They go, "Oh, no, no, no. There's three different immiscible fluids, there's glass particles and there's also air bubbles in there." The real world is a lot more complicated and that's why a lot of sensor systems and research never make it out of the labs.

In 2014, I successfully applied for an academic position at the University of Nottingham in engineering. The challenge I set myself was how to get a sensor technologies out of the lab and into a factory. And about that time, within food and drink and process manufacturing, Industry 4.0, digital manufacturing, smart manufacturing, all these initiatives were starting. I'd always been interested in AI, machine learning, and I realised it was something we could use, because one of the challenges with the sensors, especially ultrasonics, is turning measurements into information on your materials or process. Whatever sensor you use, you get a signal, you get a measurement but you have to convert that to something about the process or the materials: you need a model.

So when we started playing around with machine learning, we realised this was a statistical question and if you could get enough data, you could start unrolling some of the complexities. The challenges now are how we collect and represent data – how do we label that data? You get a lot of data but labelling is difficult. How do you have trust in those models? How do you have explainability in those models? How do you regulate a predictive model? So these are active areas of research for our team.

MP: Is this still working with ultrasound?

NW: We still do a lot of ultrasound but in the last few years we've also developed expertise in optical sensors as well: near-infrared spectroscopy, basic colour imaging. And as well as the technical side, the interest is the barriers in terms of skills and experience for people to use these – and the costs. A lot of the food sector is small and medium size enterprises and, to them, even £1,000 for a new piece of technology is a lot unless there's a clear business benefit.

MP: Are you still working on factory cleaning and allergens?

NW: When I came to Nottingham, I met an academic from Loughborough University who was using ultraviolet heating to look at fouling in equipment and I said I'd been doing a bit on ultrasound, so we met with a company that wanted to explore this and it resulted in an Innovative UK project.

The idea behind it was that if you look at any processing facility in terms of fouling, it's either pipe work or tanks. The tanks could be mixing vessels or spray dryer, or the pipe work could be heat exchangers. So the idea is that for any big open space like a tank, we can put in a UV sensor. For any closed pipe, we'd use the ultrasonic sensor, my speciality. Then you can develop machine learning models to predict if the fouling is there or not and, importantly, how long will the cleaning take to remove it? Suppose you run your dishwasher for two hours: it might have been clean after 15 minutes. But you've been paying for all the water, the energy for another hour and 45 minutes. Then imagine that at the scale of cleaning a food processing line. Every time you clean the amount of water chemicals and energy used is enormous.

Then add the idea of mass customisation. A concrete example of mass customisation is one of the companies we've worked with: they make a seasonal dessert, like a brandy butter, and years ago they would make just one of it. Now, over the years, they've diversified the product range: low-sugar ones, low-fat ones, ones with different ingredients... and where they once had just one production run in a day, making one huge batch, they're now maybe making four or five smaller batches. They have to clean between each batch because there could be cross contamination: allergens or lactose, for example. The problem is if they're over-cleaning every time because they don't know when the equipment's actually clean. So the need is to be able to monitor and optimise each cleaning process.

As we were working on that project, allergens kept coming up and we realised you weren't going to solve that with what we had, so we started developing expertise in near-infrared spectrosocpy. The hardware has become very cheap over the years and it's more mobile and can be connected to the cloud.

Another feature of our work is answering the right question. The standard idea of using sensors in process engineering focused on PAT, Process Analytical Technologies. This is about installing high tech pieces of instruments that work really well in the lab and adapting them to work in factories. But, actually, our way of thinking is, don't worry about the technology, first think what the question is you're trying to answer. So in cleaning a factory the question is, is my equipment clean, yes or no? It's not about the composition of the fouling material. And once you've got a simple question, you go back to what is the cheapest sensor system that you can develop to give you that answer, is it clean?

That's what we do differently. We try to use low cost sensors, not high tech, state of the art, super resolution stuff. It goes back to the fact that a lot of food producers are SMEs. Potato growers and processors are not going to invest tens of thousands on these technologies.

MP: Has anything surprised you?

NW: A few years ago we had a researcher working on an ultrasound project who had never worked on ultrasound before: they were a data scientist. I said, "Look, here's all this data, these wave forms. Knock yourself out." And the first thing they did was not to look at it like a sound wave. If you think of a sound wave in an Excel spreadsheet, you've got an x-axis and a y-axis. It's two columns. Traditionally we had always seen this as a signal but they saw it as a feature space and started analysing that wave form very differently to our previous work. To me, at the time, I was like, wow. We got a really interesting paper out of that and showed that that method had advantages and something worth exploring a lot more in research.

The learning point was that it's sometimes really good to get your problems tackled by people who've never looked at it from your perspective. Getting someone's perspective that's not miles away, in terms of discipline, but different enough. Get them to come in and look without me saying, "This is how I would have done it." So now if I've got PhD students starting up or researchers coming in to tackle problems, I try and stand off for a bit and let them just have a play, because they might come up with something really new.

When we're recruiting for researchers or PhDs, I'm always looking to see what's in their backgrounds that will bring a different perspective. If you want to do things differently, you need people who think differently. We hear about diversity all the time but it's just not just important because it's the right thing to do. It does actually produce better results and better, new ideas.

MP: What advice would you give to ECRs in your field?

NW: Everyone's going to give you advice, all the time, about their own careers and what made them successful. But every person has a different journey and when they started their journey it was a different time and a totally different world. So listen to all this advice but ultimately trust yourself to come up with your own plan. There's absolutely loads of ways to be successful and the key is to figure out what success means to you.

However, if I could go back 10 years and give myself advice it would be: be more organised. It's really critical, especially as you move forward in your career and you've get involved in more projects and take on line management responsibilities. You've got to be organised and you've got to have a system to make sure you prioritise your work effectively. It's very easy in academia to spend a lot of time doing things that aren't that important or just doing things that appear urgent. So be strategic, focus on the big activities that add value and support you colleagues.

And invest in yourself, your growth. Read books about personality types, productivity, how to deal with conflict, how to plan and leadership skills. Take ownership of your personal development and have a growth mindset.

And my overall advice is to be a good person to work with and support people. It's very easy in academia just to think about yourself and your own journey but one of the most rewarding aspects of my career is watching my students and colleagues grow.