Inside **neural networks**

And how they are helping organisations make better decisions.

UNIVERSITY OF CAMBRIDGE
Cambridge Service Alliance

IfM MANAGEMENT TECHNOLOGY POLICY

Cambridge Service Alliance doctoral student, Tim Pearce, explains how his work is contributing to advances in neural networks and how they are starting to help organisations make better decisions.

One of the distinctive things about the Cambridge Service Alliance is the wide range of topics it covers. As well as tackling strategic issues such as business model innovation or digital transformation, we are not afraid to delve inside the black box of the new technologies which are going to reshape our lives in the coming years. Being able to understand how they work – and contribute to their development – means that we are better placed to see the organisational opportunities and challenges these technologies present.

Neural networks – the state-of-the-art in the AI world – are one of those developments likely to bring about change on massive scale. Although they have been around for a while, it was arguably DeepMind's success with AlphaGo in 2016 that helped bring them to public attention. Conventional AI had been struggling for years to master Go, the most complex board game ever devised, but its best programmes were only as good as not very good humans. The sheer number of possible moves and the difficulty in evaluating the strength of each was just too much information for the old AI to deal with.

Neural networks (so-called because they were inspired by the way the human brain makes connections) are better able to learn these highly complex situations and understand the effect of behaviours within it. For organisations, this potentially means being able to make better decisions about almost every aspect of their business – procurement, manufacturing, maintenance, supply chain, service delivery and customer experience – as well as being the driver behind eye-catching innovations such as autonomous vehicles.

Improving neural networks

However, while our understanding and application of neural networks are progressing at speed, there is still much work to be done. One of their drawbacks is that while they are very good at giving you an answer, they aren't so good at telling you how sure they are about that answer. By using advanced mathematical tools (specifically, a Bayesian framework) we are helping them to get better at recognising and quantifying their uncertainty.

We have been testing our methods by training a neural network on 50,000 images of ten different items of clothing, while doing our best to confuse it. We only showed it eight of the ten types of clothing (withholding trousers and training shoes), we threw in some pictures of other things such as birds, cats, cars and numbers and we disguised some of the pictures of clothes by changing their colour or rotating them at strange angles. We also bombarded the network with 'noise' to see how resilient it would be under attack. Under these testing circumstances, our optimised network performed far better than conventional neural networks.

Making robots smarter, faster

Another area we are exploring is reinforcement learning in robotics. This is when a robot is given a task which it has to learn from scratch, using trial and error. In a method akin to puppy training, the robot is given a point (or reward) whenever it does what you want it to do until it is performing a complete task. This, however, is a very inefficient way of learning.

AlphaGo, for example, took millions of hours of gameplay before it was able to beat the human Go champion. If we want to develop these applications for applications such as smart robotics, we need a more efficient way of doing it.

When we learn a task, we generally bring quite a lot of prior knowledge with us; we use models of the world to predict what effect our actions are likely to have. In machine learning, we can do something similar by giving the robot a model to work from. Using these techniques, for example, we were able to reduce the time it was taking a robotic arm to learn how to move a cup across a table from days to an hour.

To find out more about our research into neural networks, contact:
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Aircraft assembly line Credit: iStock

Managing inventory in the complex world of aircraft manufacturing

If this all sounds a bit theoretical, we are also working on a very real-world problem: helping an aircraft manufacturer manage its inventory more efficiently. This is a highly complex task with thousands of parts arriving at its production lines from all over the world. If a critical component fails to turn up on time, it will cause expensive downtime and, potentially, late delivery of the aircraft to the customer. But if too many parts arrive before they are needed, additional storage may become a cost.

By using neural networks on two years' worth of product orders – including details of the parts, their suppliers, the date they were ordered, the date they were due to arrive and their actual delivery dates – Pearce and IfM MPhil student, David Ratiney, are developing a reliable way of predicting when an order is likely to arrive.

A previous project had attempted to solve the same problem using conventional machine learning techniques. By using neural networks and some of the more advanced approaches to data processing we have been able to increase the accuracy of predictions by around 7%.

This project is a good example of the role neural networks will increasingly play across a wide variety of organisational functions.

As well as helping to optimise the efficiency of supply chains, both upstream and downstream, they can also improve things like customer experience by predicting customer behaviour and by assigning appropriate levels of resourcing to deliver optimal customer service.

And they will, of course, be pivotal in developing next-generation robotics, both inside and outside the factory environment.

As well as helping to optimise the efficiency of supply chains, both upstream and downstream, [neural networks] can also improve things like customer experience by predicting customer behaviour and by assigning appropriate levels of resourcing to deliver optimal customer service.

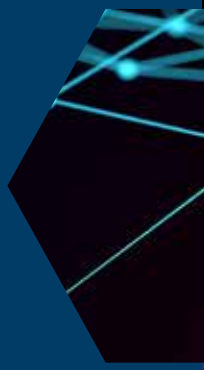
About the authors

Tim Pearce is a PhD student with the Cambridge Service Alliance, researching the application of advanced data analytics techniques to the manufacturing industry. These include statistical, machine learning, and text mining methods.

Tim has an M.Eng from Durham University, with a masters project in artificial intelligence. He has worked in the finance sector with EY (Ernst & Young), with whom he qualified as a Chartered Accountant. He is recently been working with Cambridge AI company, Prowler, on reinforcement learning.

David Ratiney graduated from the École CentraleSupélec with a Masters in Electrical Engineering. His first job experience in data and analytics was an internship at Infosys (second largest Indian IT company) where he worked on Optical Character Recognition using supervised learning methods. He is currently working on Supply Chain Disruption Prediction using Bayesian Techniques as part of his MPhil Research project.

This article is based on: 'Uncertainty in Neural Networks: Bayesian Ensembling' by Tim Pearce, Mohamed Zaki, Alexandra Brintrup, Andy Neely (2019) https://arxiv.org/abs/1810.05546
and 'Expressive Priors in Bayesian Neural Networks: Kernel Combinations and Periodic Functions' by Tim Pearce, Mohamed Zaki, Alexandra Brintrup, Andy Neely (2019) presented at Uncertainty in Artificial Intelligence (UAI), 2019 https://arxiv.org/abs/1905.06076



CAMBRIDGE SERVICE ALLIANCE (CSA)

A unique collaboration between the University of Cambridge and some of the world's leading businesses to design and deliver the services of the future. Its focus for 2019 is service transformation through digital innovation.

"Our partnership with the CSA will create a wealth of new opportunities for HCL and our customers. Working alongside the world's foremost academics and leading organizations, we aim to pioneer new digital solutions for the next decade, today. Through these efforts, we will uncover new ways in which digital technologies can empower and transform businesses. We are also excited to be able to uniquely offer our customers the benefits of being a member of such a prestigious alliance."

Ashish Gupta, CVP and Head of EMEA, HCL Technologies

"CEMEX has started its journey to design new services focusing on improving our customers' experience. The Design Lab Services was launched to research, diffuse and implement new approaches and best practices for service design. We are also committed to collaborating with the best universities and experts around the world on applied research and innovation projects to get prepared for the digital revolution."

Martin Adolfo Herrera Salado, Digital Enablement, Business Consulting Services

"One of the key things about the Alliance is the non-competitive nature of the partners within it. That allows us to move away from some of the more traditional IP and confidentiality rules, to openly share our challenges, dig beneath the surface of some of the hype about digital and get into the nuts and bolts about how we really deliver it and the challenges we all face.'

Caroline Burstall, Supply Chain Manager For Industrial Power Systems, Caterpillar

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