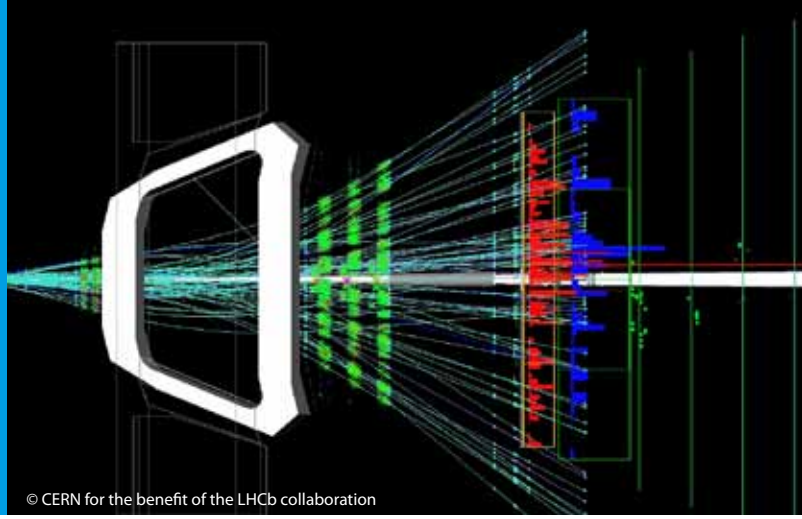
The Role of NeuroBayes in the Scientific Environment



Blue Yonder software participates to enormous progress in particle physics

The discovery of the Higgs boson

Particle physics was big news in 2012. On the 4th of July the world's attention was focused on CERN, the European particle physics laboratory and the world's largest research facility, as scientists announced that they had discovered the long-sought Higgs boson amongst the huge quantities of data produced by the Large Hadron Collider (LHC). As the results were presented to a packed CERN auditorium, the usually reserved audience of physicists broke into spontaneous cheers and applause. And no wonder they're excited. This discovery, the greatest prize in modern science, marks the end of almost half a century of investigation that was only finally resolved using the largest and most sophisticated scientific device ever constructed.

The Large Hadron Collider beauty experiment

About two hundred metres under the countryside between Lake Geneva and the Jura Mountains runs a 27 kilometre tunnel housing the world's most powerful particle collider, the LHC. There is nothing ordinary about this machine and it's hard not to be impressed by the mind-boggling list of facts and figures that scientists rattle off when they talk about it. It has variously been described as the coldest place in the Universe (thanks to its decidedly chilly operating temperature of -271°C) and the fastest place on Earth (the protons zip round the ring at 99.9999991% of the speed of light), and the collisions it produces briefly form the hottest spots in the galaxy.

But getting results from the LHC doesn't just involve big engineering challenges. One of the most difficult problems that physicists have had to overcome is how to handle the vast datasets produced by the LHC's detectors. The LHCb experiment, one of the four office block-sized detectors at the LHC, witnesses more than 40 million collisions every second. Each collision produces an explosion of new particles that are recorded by the detector and converted into around 40 kilobytes of digitised information. So if LHCb wanted to record every collision it would require around 1.5 terabytes of storage space per second – or tens of thousands of petabytes every year.

Data storage on this scale is completely impossible. In fact LHCb can only read out about 2,000 collisions per second, or a still large but more manageable 2 petabytes per year. This means that for every collision that is saved to disk, 19,999 are thrown away. The obvious question then is, how do you decide which collisions to keep?

The limits of conventional software

The particles that LHCb physicists are interested are very rare, and are only produced in a small fraction of collisions. Physicists overcome the problem of huge datasets and rare particles by writing software called "triggers". These triggers perform a very fast analysis of each collision to see if it contains an interesting particle. This is traditionally done by imposing a series of requirements or 'cuts' on the properties of particles in the collision. For instance, you might require that a particle have energy larger than a certain value or leave signals in a particular part of the detector. If a collision contains a particle that passes your requirements, then the trigger 'fires' and the collision is saved. If not, the data is discarded.

NeuroBayes detects 'beauty quarks'

The problem with these simple cut-based triggers is that they often miss more difficult to spot particles, or introduce biases into the data. This is where NeuroBayes, Blue Yonder's advanced predictive analysis suite, is helping physicists overcome the problems that accompany 'Big Data'. The Blue Yonder software solution mimics the way the human brain works and can be trained to recognise patterns in data or, in the case of particle physics, spot an interesting particle amongst the hundreds of ordinary ones in a collision.

blue yonder

Forward looking. Forward thinking.

LHCb physicists used NeuroBayes to sift through the trillions of LHC collisions in search of the rare 'beauty' particle. After these beauty particles are produced they only exist for a few trillionths of a second before disintegrating, so spotting them amongst the hundreds of other particles in a collision is a daunting task.

Traditional methods missed a large fraction of these beauty particles which made measurements less accurate and prone to biases. But where the traditional trigger failed, NeuroBayes was able to succeed. The machine-learning capabilities of Blue Yonder's solution were used to train NeuroBayes to recognise beauty particles amid the huge quantities of uninteresting background noise. The solution exploited all of the available information to achieve an impressive boost over the traditional approach. As a result the scientists were able to identify a large sample of beauty particles and make a world-beating measurement.

Not only did NeuroBayes demonstrate remarkable performance in recognising these rare signals amid huge quantities of data, it also did it at impressive speed. The networks were able to churn through 20,000 collisions every second and spot particles that only appeared at a rate of one in a million.

Mastering Big Data with NeuroBayes

NeuroBayes is also finding other applications in the LHCb experiment. The NeuroBayes software package is being used to improve the ability of the LHCb detector to distinguish different types of particle by optimising the way that the information produced by the machine is analysed. This will allow researchers to spot ever-rarer particles and make measurements that would otherwise have been extremely challenging. As we enter the most exciting period of scientific discovery in a generation, NeuroBayes is proving invaluable, both in pushing back the frontiers of fundamental physics and overcoming the challenges modern enterprises face with Big Data.

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