

# DR WHO? PEERING INTO THE BLACK BOX OF ARTIFICIAL INTELLIGENCE

The complexity of machine learning makes explaining computer-assisted diagnoses increasingly difficult. **FUJITSU LABORATORIES** has developed technology that demystifies key parts of its system's learning process.

**Electronic forms of medical data** are proliferating and it's helping computer technology draw useful medical conclusions even faster than doctors. Over the last five years the availability of speedy, low-cost processors has activated a key driver artificial intelligence (AI) technology, 'deep learning'. Deep learning occurs when algorithms approximate the brain's neural networks and 'learn' by spotting patterns in massive datasets. But, handling huge datasets in this way means letting machines do the heavy thinking for doctors, raising all sorts of questions. To tackle these issues, Fujitsu Laboratories is making deep learning both better and more transparent through their AI platform known as Zinrai.

One of their latest software advances, Deep Tensor, has helped AI achieve medical results previously thought impossible. By training Deep Tensor with sources such as open databases of genetic markers, Fujitsu's technology can give diagnostic advice with startling precision — earning an accuracy score of 96% during an evaluation of mutation effect prediction algorithms done in collaboration with Kyoto University.

Deep Tensor technology works by expressing datasets as a network of interconnected

nodes in a graph structure. The graphs are then transformed into multi-dimensional arrays, or tensors, that are easier to sort into categories using deep learning. Neural-like networks form links between layers of nodes, arranged in hierarchies from least-to-most detailed, to process input data. Because these layers can grow into the hundreds, the resulting networks can be inconceivably complex. The software can then identify significant features, such as markers for pre-cancerous tumours, that might elude even the most experienced oncologist.

## Understanding AI advice

Justifying an AI diagnosis to a concerned patient, however, can be problematic. "Deep Tensor can predict links from a genetic mutation to an illness, even if no direct connection is known," notes Seishi Okamoto, Deputy Head of the Artificial Intelligence Laboratory at Fujitsu Laboratories. "But it's also a black box — it's hard to explain why it produces certain results."

As a result, Fujitsu Laboratories has developed 'explainable AI', a smarter way to explain the inner workings of these systems. They've incorporated a more easily

readable knowledge graph into their technology. Similar to artificial neural networks, knowledge graphs place high value on relationships between information collected from a variety of sources, particularly for academic literature on genomic medicine. And because information sources like this can be represented using descriptions similar to natural language, these values are easy for doctors or researchers to check.

In one example, a custom-built knowledge graph technology was used to search Deep Tensor results. Using it Fujitsu Laboratories was able to identify factors that influenced the machine's conclusions by looking for similarities between features obtained from different input tensors. They did this by extracting 'partial' graphs from the main dataset containing regions of localized data nodes. By correlating the partial graphs' characteristics with information from the knowledge graph, clues emerge about how the computer arrived at its digital diagnosis.

To demonstrate the potential of this approach for medical applications, Okamoto and colleagues used open data to train Deep Tensor on the connections between

genetic mutations and the causes of disease. When an unknown mutation was analysed, the team showed that it was possible to get a simultaneous readout of the academic references and genetic catalogues behind the machine's inferences (right).

## Privacy built in

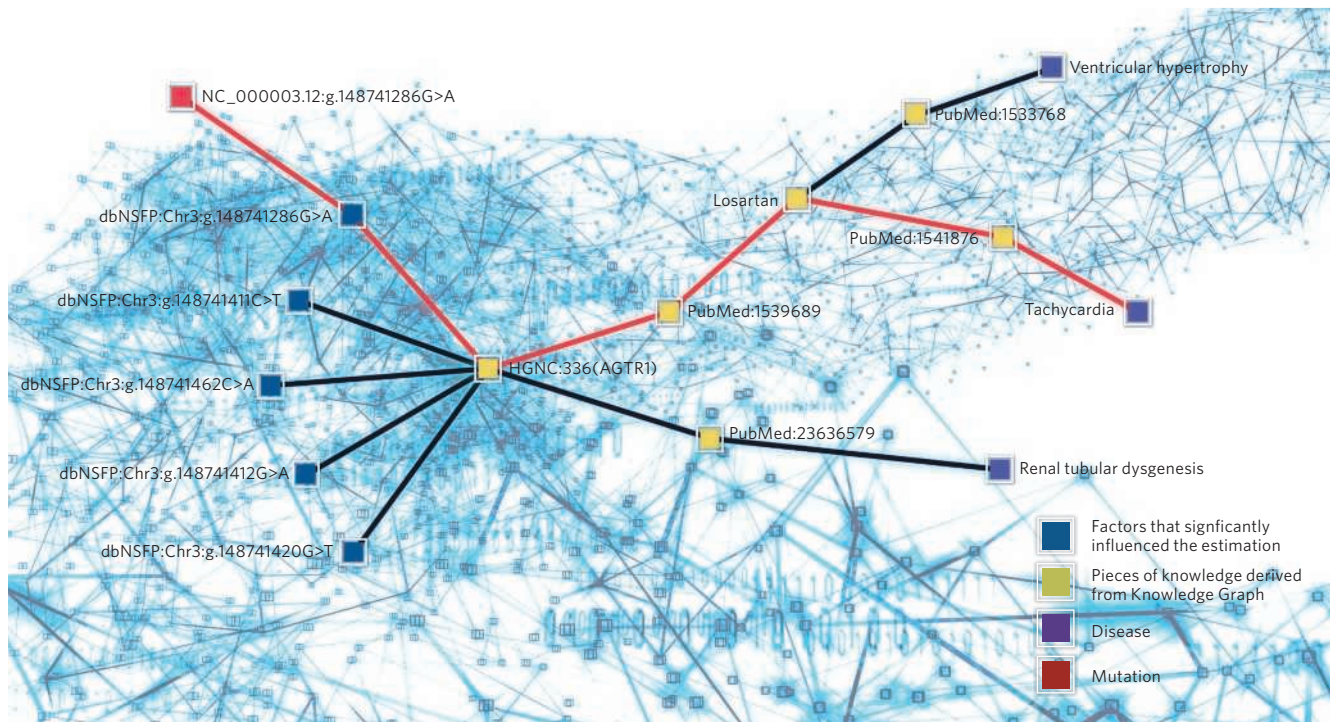
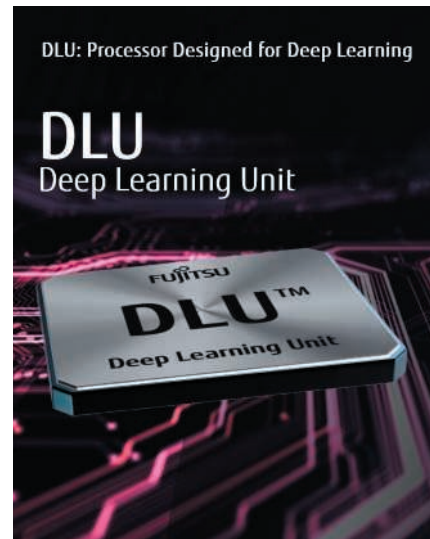
Deep Tensor's learning system will also help protect delicate medical work from cyber-attack. "It's difficult for conventional machine learning methods to find the significant features of events such as cyber-attacks, because the number of characteristics — IP addresses or event durations, for example — vary widely, even among similar incidents" says Okamoto. "Deep Tensor doubles the accuracy of intrusion detection by instead focusing on the relationships between characteristics, and extracting their structures with a new type of mathematical technique."

## Hardware for big data

Doctors wanting to use this technology to progress beyond well-defined gene mutations will require cutting-edge software and hardware able to handle extremely broad datasets.



Nobuyuki Igata, Seishi Okamoto, and Fumihiro Maruyama from Fujitsu Laboratories.



Often this will mean finding the right datasets and identifying solutions within a defined set of solution parameters. Unfortunately, with complex health problems that have very wide search parameters — for instance, spotting an effective drug molecule among 40 million possibilities — even powerful computing can get stuck working on specific answers. This is called the local energy minima and the answers from this might differ from the overall best answer.

To meet this challenge, Fujitsu Laboratories has invented a 'Digital Annealer' — a hardware product designed to strengthen the system — to shake up typical optimization processes. The new computer architecture uses digital circuits running in parallel to evaluate many solution candidates at once. Repeatedly adding mathematical constants to the candidate's scores helps the searches avoid local energy minima, even at speeds that rival quantum computers.

Fujitsu has also announced its new ultra-efficient AI-specific microprocessor, called the Deep Learning Unit (top right), and plans to take this technology to market by fiscal 2018. Both the Digital Annealer and Deep Learning Unit will become important parts of its 'human-centric' AI platform Zinrai.

But, Fujitsu knows that if it wants to enter the healthcare sector one of its most important steps is to win people's trust with its knowledge graph technology. "Winning

consumer acceptance is a must for commercialization, and that's why we need to explain methods such as Deep Tensor," says Okamoto. "We're always trying to make sure that humans stay in the loop too." ■

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