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Sparse Modeling delivers fast, energy efficient and explainable AI solutions for cutting-edge medical applications

Japanese AI specialist HACARUS Inc. is successfully utilizing its proprietary Sparse Modeling AI technology in joint projects including phenotype drug discovery, medical imaging and ECG monitors for human and veterinary applications.

HACARUS, founded in Kyoto, Japan as an artificial intelligence (AI) startup in 2014, has adapted the Sparse Modeling (SM) technology developed in universities from around the year 2000. The strength of the technology is its ability to extract features from small amounts of data and the strong interpretability of results. HACARUS believes it is the only company to utilize SM in a commercial field at this stage.

"Sparse Modeling has significant advantages over other AI technologies, including Deep Learning (DL)," said Kenshin Fujiwara, CEO and founder of HACARUS.

"One of the core strengths of our SM technology is that we can work with very small datasets. Our processes produce an explainable 'white box' result, rather than the opaque 'black box' of DL which lacks transparency in how it actually arrived at its results," Fujiwara explained.

"SM is much faster and extremely energy efficient. In one client comparison, our SM model was trained five times faster than the DL model and consumed just 1% of the power" (Fig. 1).

Phenotype drug discovery (PDD), which can lead to the identification of novel drugs without understanding the pathogenesis, is attracting increasing attention because of its potential for first-in-class drugs and improved clinical predictability. However, it generally generates very large and complex datasets.

DL was originally considered by a pharmaceutical client of HACARUS in order to increase the efficiency and speed for detecting hit compounds. However, while DL can shorten the time required for image analysis, it has significant limitations.

To analyze each compound, a separate discriminative model must be created, which may require between 20 and 40 minutes per compound. Its 'black box' process also makes it impossible to ascertain which factors affected the determination of the hit compounds.

> **Sparse Modeling has significant advantages over other AI technologies, including Deep Learning**
>
> Kenshin Fujiwara, CEO and founder, HACARUS

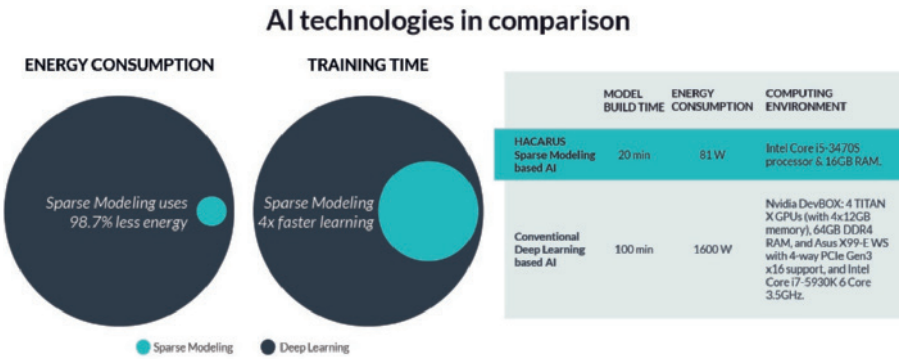

Fig. 1 | Energy consumption of Sparse Modeling-based AI vs Deep Learning-based AI. Tests have shown that for the same level of accuracy, Sparse Modeling consumes only 1% of the energy required to use a conventional Deep Learning platform.

Using HACARUS' SM system for phenotype screening meant it was possible to detect hit compounds while also identifying the influencing factors.

To reduce the time required to search for hit compounds, only the features of control were learned with the anomaly detection/change detection model.

Processing time cut to less than one minute

"This led to the analysis only requiring one common model for several different compounds, significantly reducing the time needed for processing. It was cut from up to 40 minutes per compound to less than a minute," said Fujiwara.

"To overcome the problem where the factors that led to the detection of the hit compounds could not be determined, Kullback-Leibler (KL) divergence method and Sparse structure learning were adopted between two control groups. The KL method made it possible for us to determine which feature value had changed, while the Sparse structure learning allowed the researchers to find out which features changed the correlation between them. Through these results, it is now possible to determine to what extent a feature value impacts on the outcome," he said.

From this project, the pharmaceutical company was able to obtain results that matched its initial predictions and was pleased it was able to develop new analytical techniques. Through its continued partnership with HACARUS, it hopes to further improve the performance of the model created during the project.

"HACARUS took a unique approach that only requires control data in order to successfully perform the analysis," said Fujiwara. "Another unique finding is that we are now able to pinpoint the feature values that influence the final result through the analysis. In future, we expect it will be possible to screen a variety of conditions including disease type and genetic polymorphism using patient iPSC (induced pluripotent stem cells). This technology has the potential to be utilized in medical applications that require a high level of precision."

HACARUS AI applied in other medical fields

HACARUS is also working with a number of organizations and universities in a wide range of medical projects utilizing AI and SM (Box 1).

With Ohara Pharmaceutical and a leading medical university, it is creating an AI-enabled cerebral infarction diagnosis tool which will enable rapid diagnosis of cerebral infarction even in hospitals without specialists.

HACARUS is also working with Kobe University to develop a liver cancer diagnosis support tool, and with Kyoto University to build a highly accurate AI model for the early diagnosis and prevention of cervical cancer.

Two ECG projects using SM are underway: a monitoring system for anomaly detection in human ECG signals with the German technology company ITK Engineering; and, with DS Pharma Animal Health, a non-intrusive ECG measurement

and analytics tool for animals based on a connected sheet which can capture vital heart data from standing animal paws.

Other life science projects include genome analysis, and assistance in tasks such as the identification, measurement or comparison of genomic features including DNA sequence, structural variation, gene expression or regulatory and functional element annotation at a genomic scale.

Sustainable technology

As developed nations strive for zero net carbon emissions, the power-hungry nature of DL is beginning to concern many medical organizations which rely on it for diagnostic tools. Aside from the huge amount of power consumed during data processing, computer hardware needs constant cooling to avoid heat-related breakdowns.

In one recent study at the University of Massachusetts, a life cycle assessment for training several large AI models revealed that the process can emit nearly five times the lifetime emissions of an average American car, including the manufacture of the car[1].

Fujiwara also cites a university study which says more than 100 nuclear power stations would be required if all industries globally began incorporating DL in their operations.

A comparison of HACARUS' SM system and a conventional DL technique, performed for a HACARUS client, showed that SM was far faster and far more energy efficient. A data set of 1,000 images was used by both models to create predictions. Both approaches produced comparable results, but the SM system was trained five times faster on a standard x86 system with Intel Core i5-3470S processor and 16GB RAM (Fig. 2). The DL model required an industrial grade Nvidia DEVBOX-based development platform with far more computing power and memory.

"Ultimately, the SM-based approach consumed just 1% of the energy of the DL-based approach and delivered the same level of accuracy," Fujiwara said. "The key differentiator of SM compared to other models is that it needs less data for training, it learns faster and more efficiently. Consequently, it can run on normal computing power, with significantly lower energy consumption."

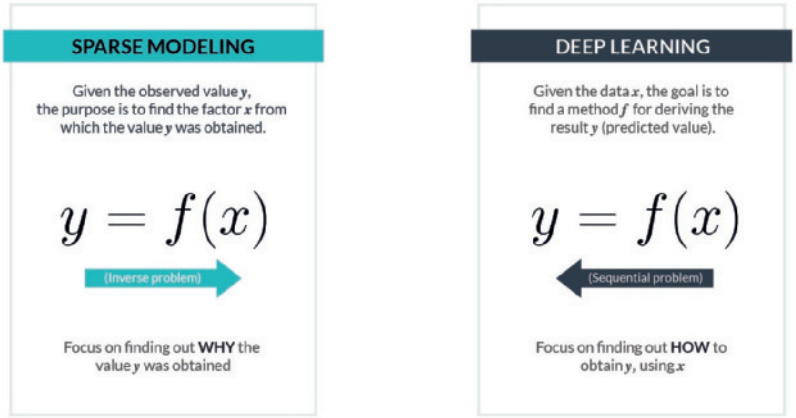

Fig. 2 | Basic concept of Sparse Modeling, compared with Deep Learning.

HACARUS believes that AI should be efficient and simple, so it is adopting a lightweight SM that is easily explained to the end user. Its solutions can bring AI to embedded low-power applications, and it can easily fit and integrate with local devices or 'Edge AI'. This advantage brings Edge AI to domains that have never been tapped before due to connectivity or compatibility limitations.

An example of this is the SM project with DS Pharma Animal Health, in which a non-intrusive ECG measurement and analytics tool for animals has been developed for veterinary clinics.

"Instead of running a Deep Learning AI in the cloud, we took some of the AI features to the edge site. The system is analyzing all the ECG data coming in real time from living animals," Fujiwara said.

SM and robotics medical collaboration with Mitsubishi

HACARUS has partnered with Mitsubishi Electric in a new SM and robotics medical collaboration for cell analysis. It combines HACARUS' expertise in SM-powered medical imaging analysis with Mitsubishi Electric's advanced industrial robots.

"The collaboration is focused on automating cell analysis lab work," said Fujiwara. "The seamlessly integrated solution includes a three-stage setup, which starts with the robot carefully preparing and transporting cell samples for examination by a digital microscope powered by HACARUS AI. Once the samples have been analyzed, recorded and classified, the robot arm automatically delivers the processed cell samples and moves to the next set of samples."

This system vastly reduces the need for human resources by providing accurate analysis with fewer errors and significantly increasing the volume of cell processing. In addition, it answers the increasing demands for remote work resulting from the COVID-19 pandemic.

A year of growth and recognition

HACARUS' Sparse Modeling is a cutting-edge technology that enables AI to deliver fast, explainable results. It is energy efficient, can bring AI to embedded low-power applications and can integrate with local devices.

HACARUS is now gearing up to take its solutions to a global audience after a year of growth in 2020. It significantly increased its staff numbers, closed its Series B financing (it has now raised ¥1.3 billion, or nearly US$12 million) and opened a new R&D hub in the Cambridge Innovation Center in Tokyo.

HACARUS has won several awards recently including a CBInsights' award in the AI 100: The Artificial Intelligence Startups Redefining Industries. It was also one of only 10 innovation companies recognized by inVISION'S 2020 innovation awards.

1. MIT Technology Review. Training a single AI model can emit as much carbon as five cars in their lifetimes. https://www.technologyreview.com/2019/06/06/239031/training-a-single-ai-model-can-emit-as-much-carbon-as-five-cars-in-their-lifetimes/ (2019).

Box 1 | Collaborations with Hacarus aim to harness the power of artificial intelligence and Sparse Modeling.

AI-enabled cerebral infarction diagnosis assistance

Highly specialized MRI image interpretation technology is required to diagnose cerebral infarction and promptly select the correct treatment. Many hospitals do not have a cerebral infarction specialist, even though they have MRI imaging equipment.

To tackle this issue, HACARUS and Ohara Pharmaceutical Co. Ltd are working together with a leading medical university to digitize specialists' knowledge and offer AI-enabled assistance in acute cerebral infarction diagnoses. Vital patient data and data from MRIs is fed into the model. Digitalization of expert knowledge will aid in rapid diagnosis, and in delivering appropriate treatment of cerebral infarction even in hospitals without specialists.

Joint research for liver cancer diagnosis support tool

A shortage of specialists possessing the required knowledge to interpret scans means the healthcare system is increasingly unable to meet a growing demand for liver cancer diagnoses. HACARUS and Kobe University are conducting joint research aiming to:

- Detect risk areas in MRI images using AI training and supervised learning.
- Perform HCC (hepatocellular carcinoma) disease type classification in risk areas.
- Create an accurate AI type classification and diagnosis support system.

SM-based anomaly detection in ECG signals

The German technology company ITK Engineering (a subsidiary of Bosch) and HACARUS have jointly developed a proof-of-concept for a personalized patient monitoring system that will evaluate ECG signals. It not only evaluates anomalies in a single patient's heart ECG in near real-time, but also provides immediate comparisons with the expected normal ECG curve.

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