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Mitsubishi Electric's New Quantum Artificial Intelligence Technology Uses Automated Design to Realize Compact Inference Models

Can be incorporated in first-ever application for terahertz imaging
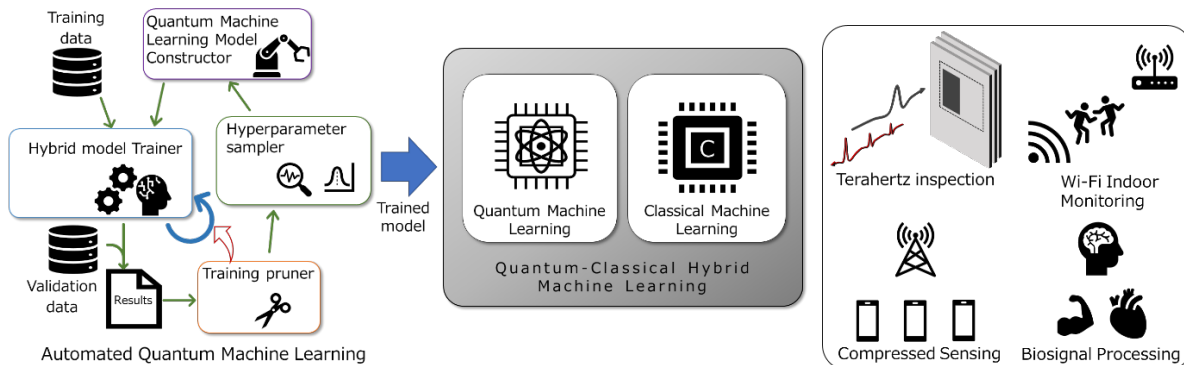
Newly developed quantum AI technology   Example applications

TOKYO, December 2, 2022 – Mitsubishi Electric Corporation (TOKYO: 6503) announced today its development of a quantum artificial intelligence (AI) technology that automatically designs and optimizes inference models to downsize the scale of computation with quantum neural networks. The new quantum AI technology can be integrated with classical machine learning frameworks for diverse solutions.

Mitsubishi Electric has confirmed that the technology can be incorporated in the world's first[1] application for terahertz (THz) imaging using ultra-high-frequency waves[2] to perform non-destructive inspections by exploiting properties such as the high penetration of radio waves and the high directivity of light waves. It also can be used for indoor monitoring in which Wi-Fi signals are used to observe room environments for human movements. Other potential applications also are possible, such as compressed sensing to retrieve original data from mixed measurement data and biosignal processing for brain-computer interfaces.

Mitsubishi Electric's new quantum machine learning (QML) technology realizes compact inference models by fully exploiting the enormous capacity of quantum computers to express exponentially larger-state space with the number of quantum bits (qubits). In a hybrid combination of both quantum and classical AI, the

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[1] According to Mitsubishi Electric's research as of December 2, 2022
[2] Electro-magnetic wave having a frequency around 0.1-10THz

technology can compensate for limitations of classical AI to achieve superior performance while significantly downsizing the scale of AI models, even when using limited data.

Rapidly developing quantum computers are expected to surpass classical computers by exploiting quantum physics to manipulate states of qubits in a highly parallel manner. Major breakthroughs are envisioned in data analysis, AI development, etc. for purposes such as large-scale optimizations and new material design. Classical machine learning technologies[3] based on deep learning[4]—the cornerstone of current AI—have shown excellent performance but require costly computing resources and often do not achieve full potential if training data[5] or resources are limited.

Mitsubishi Electric will partially introduce its quantum AI technology and related achievements at a tutorial session of the IEEE Global Communications Conference (GLOBECOM) 2022.

Features

1) Compact models for QML achieved through automated design and optimization
- Automated design of quantum/classical hybrid AI model uses multi-objective Bayesian optimization.[6]
- Joint optimization of QML models and hyperparameters,[7] such as number of qubits and gate depths, contributes to model compactness.
- Automatically designed quantum-classical hybrid AI model achieves high performance in spite of compact size.

2) QML-assisted THz imaging achieves high accuracy
- Use of quantum AI in non-destructive THz imaging application raises performance to 99.6% accuracy, up from 97.6%, and achieves excellent feature extraction.
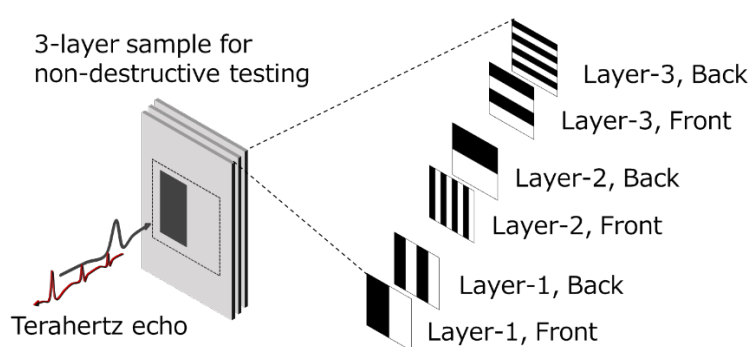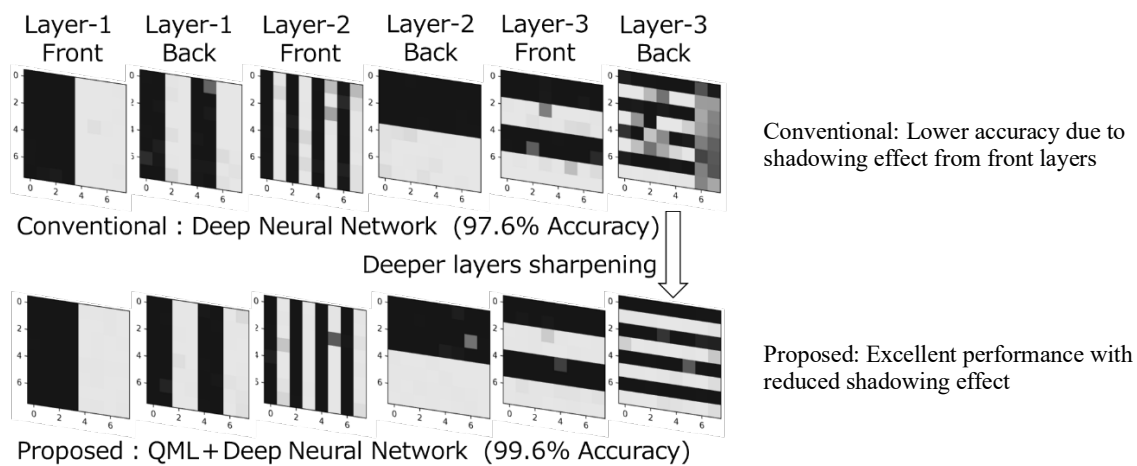

Example of THz imaging

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[3] Machine learning designed to run on conventional computers
[4] Machine learning method to train computers for voice recognition, image identification, motion prediction, etc.
[5] Dataset containing signals and/or associated labels that AI models and machine learning algorithms can use to solve tasks
[6] Optimization method for exploring potential solutions according to an acquisition function by constructing a Bayesian model to predict the probabilistic relation between an objective function and search space
[7] Manually set parameters for machine learning algorithms

Conventional: Lower accuracy due to shadowing effect from front layers

Conventional : Deep Neural Network (97.6% Accuracy)

Deeper layers sharpening

Proposed: Excellent performance with reduced shadowing effect

Proposed : QML＋Deep Neural Network (99.6% Accuracy)

Performance improvement by Mitsubishi Electric's quantum AI in THz imaging

3) *Applicable in diverse practical tasks*

- In an application to monitor human movements using Wi-Fi access points, a compact quantum neural network model using 10 parameters performed as well as a large-scale deep neural network model using about 40,000 parameters.
- Use of quantum AI in a compressed sensing application for retrieving original data from mixed measurement data achieved excellent denoising in multi-device wireless-access systems.
- Quantum AI in biosignal processing for brain-computer interfaces achieved higher accuracy than classical machine learning through validation with various data sets.

Future Plans and Prospects

Mitsubishi Electric will further develop its QML technology as well as continue expanding its Maisart[®8] AI technology, targeting practical applications in a wide range of industrial fields such as factory automation, air conditioning, building systems and mobility.

About Maisart

Maisart encompasses Mitsubishi Electric's proprietary artificial intelligence (AI) technology, including its compact AI, automated-design deep-learning algorithm and extra-efficient smart-learning AI. Maisart is an abbreviation for "Mitsubishi Electric's AI creates the State-of-the-ART in Technology." Under the corporate axiom "Original AI technology makes everything smart," the company is leveraging original AI technology and edge computing to make devices smarter and life more secure, intuitive and convenient.

Maisart is a registered trademark of Mitsubishi Electric Corporation.

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About Mitsubishi Electric Corporation

With more than 100 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Mitsubishi Electric enriches society with technology in the spirit of its "Changes for the Better." The company recorded a revenue of 4,476.7 billion yen (U.S.$ 36.7 billion*) in the fiscal year ended March 31, 2022. For more information, please visit www.MitsubishiElectric.com
*U.S. dollar amounts are translated from yen at the rate of ¥122=U.S.$1, the approximate rate on the Tokyo Foreign Exchange Market on March 31, 2022

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[8] Mitsubishi Electric's AI creates the State-of-the-ART in Technology

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