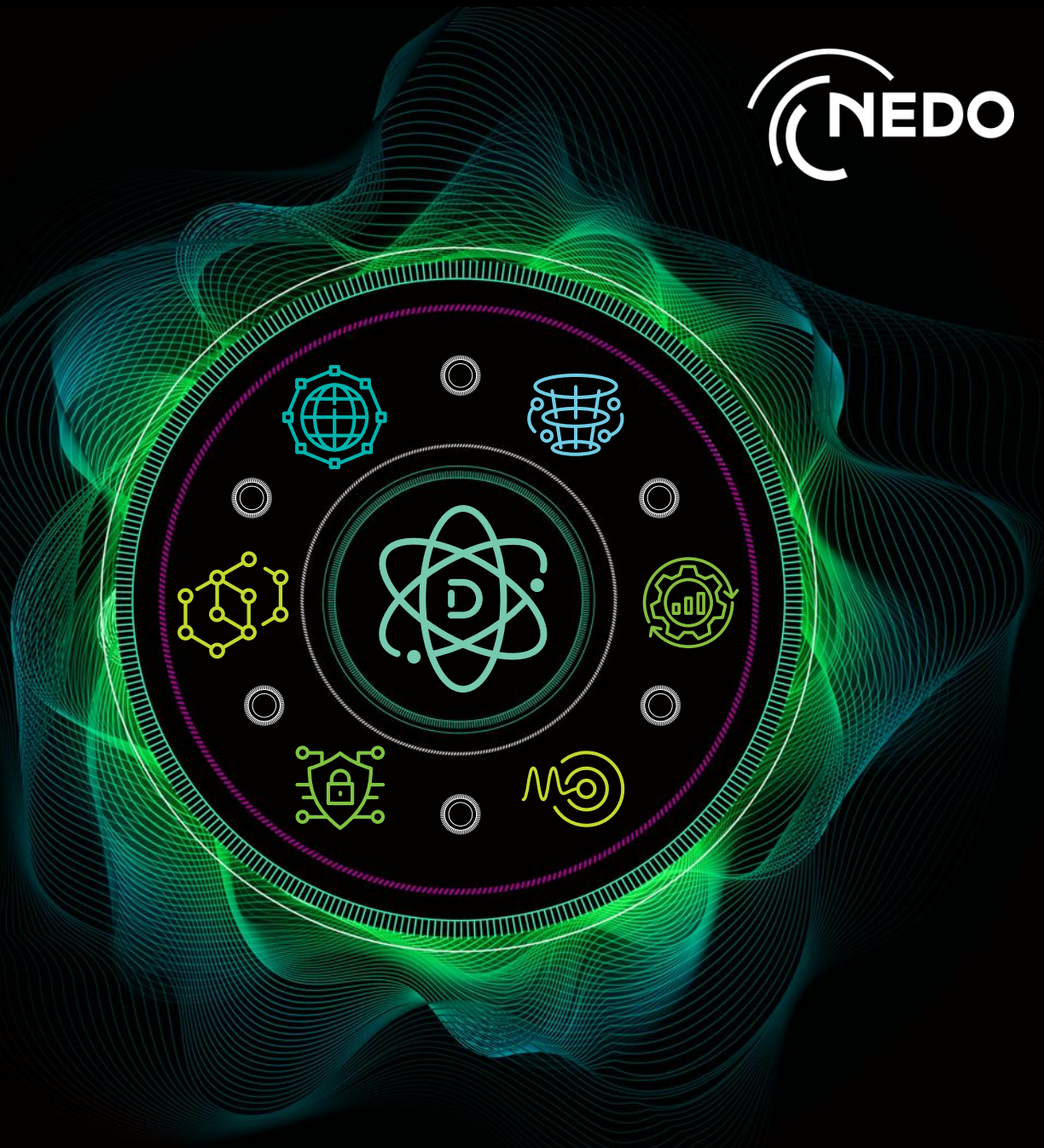
Quantum Computing Use Cases

Communication Service Fault Diagnosis System Using Quantum Kernel Learning

SoftBank Corp.



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Other
Method	AI
Process	model learning
Category	Gate*

Background

- In recent years, in addition to the advancement of corporate digital transformation (DX) and the penetration of remote work, the combination of ultra-high-speed, large-capacity transmission technology and edge computing technology in Beyond 5G/6G is expected to realize a data-driven society, and **the quality of the communication network is one of the important indicators** to support them.
- Due to the expansion of network demand and other factors, the equipment configurations of telecommunication carriers are becoming larger and more complex. **Automation using advanced computing technology is being studied, but classical computers have issues with efficiency and vulnerability to energy consumption and computational complexity, and quantum computers are expected to be more advanced and faster,** using AI called MLOps*.

MLIps *: Coined from the combination of machine learning (ML) and operations (Ops), this term refers to a pipeline in the development and operation process using machine learning.

Issues and motivation to be solved

- **Demonstration of a communication service fault diagnosis system using quantum machine learning** was conducted using a data set extracted from logs of a system operating on a commercial network.

Reference: SoftBank Corp. "Demonstration of communication service fault diagnosis system using quantum machine learning" (https://www.softbank.jp/corp/technology/research/story-event/062/)
*Gate（gate-based）: A computing approach in which operations are applied sequentially to qubits to perform calculations. Similar in concept to logic circuits in classical computers, it can address a wide range of problems.

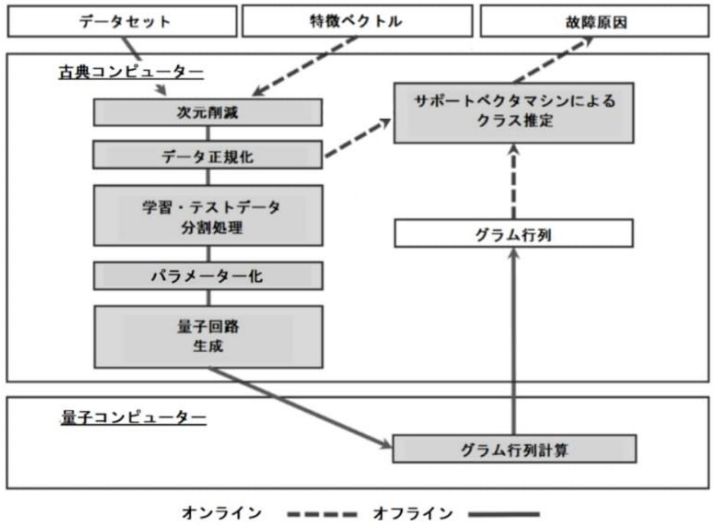
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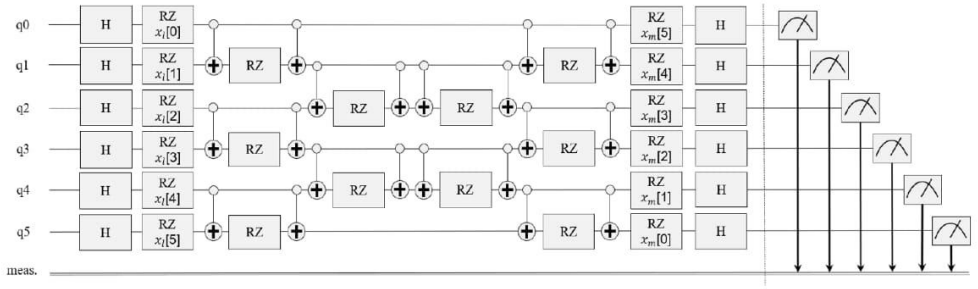
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Problem setting as a quantum computer

- **The quantum computer is used to generate a Gram matrix by performing a round-robin inner product calculation on the number of failure patterns in the training data** while performing an operation to estimate the cause of failure for an unknown feature vector in an online process.
- **A unique quantum entanglement control circuit (patent pending) has been devised for kernel generation by quantum kernel learning, and the performance of quantum computers has been derived for more general-purpose data.**
- HW utilizes **IBM's superconducting gated quantum computer (IBM Quantum System One: IBM-Kawasaki 127 qubits) and Q-CTRL's error suppression system**



Scope of use of quantum computers in this initiative



Proposed Quantum Kernel Learning Circuit

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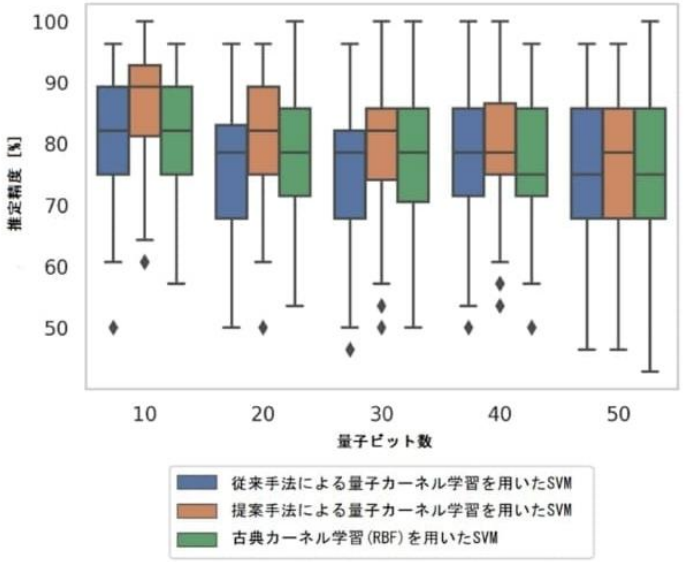
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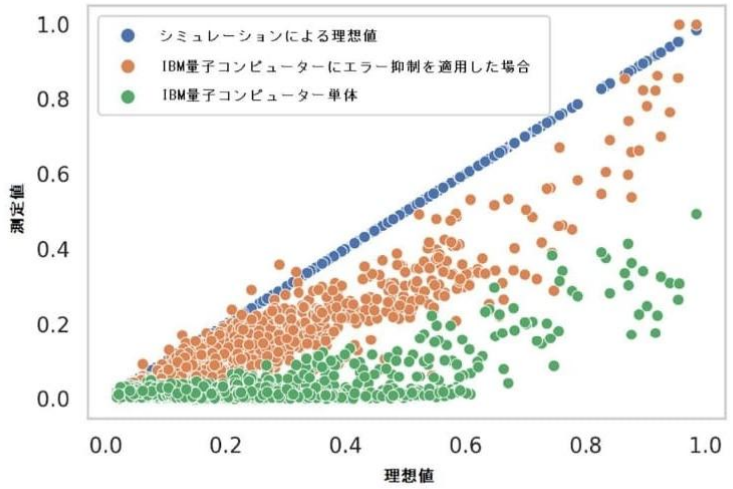
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Expected business benefits

- The proposed method shows superior performance compared with SVM using conventional quantum kernel learning and SVM using classical kernel learning. Comparing the average values of the evaluation results for all qubit numbers, the conventional quantum kernel learning is 77%, the proposed quantum kernel learning is 81%, and the classical kernel learning is 78%, and the proposed method shows the best results.
- Improved quantum kernel learning algorithms and error suppression demonstrate the practical performance of quantum computers.



Comparison of failure cause estimation performance evaluation by a tensor network simulation



Effect of Error Suppression in Gram Matrices at 30 Qubits

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More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

New Energy and Industrial Technology Development Organization (NEDO)
AI and Robotics Department (e-mail: quantum_ai@ml.nedo.go.jp)

This collection of use cases was obtained as a result of the work commissioned by the New Energy and Industrial Technology Development Organization (NEDO) "Cyber-Physical Development Business of Quantum/Classical Hybrid Technology/Study of Use Case of Quantum Technology" and the “Post-5G Information and Communications System Infrastructure Reinforcement R & D Project (Quantum Industrialization)/Comprehensive Study for Promoting the Industrialization of Quantum Computers”.