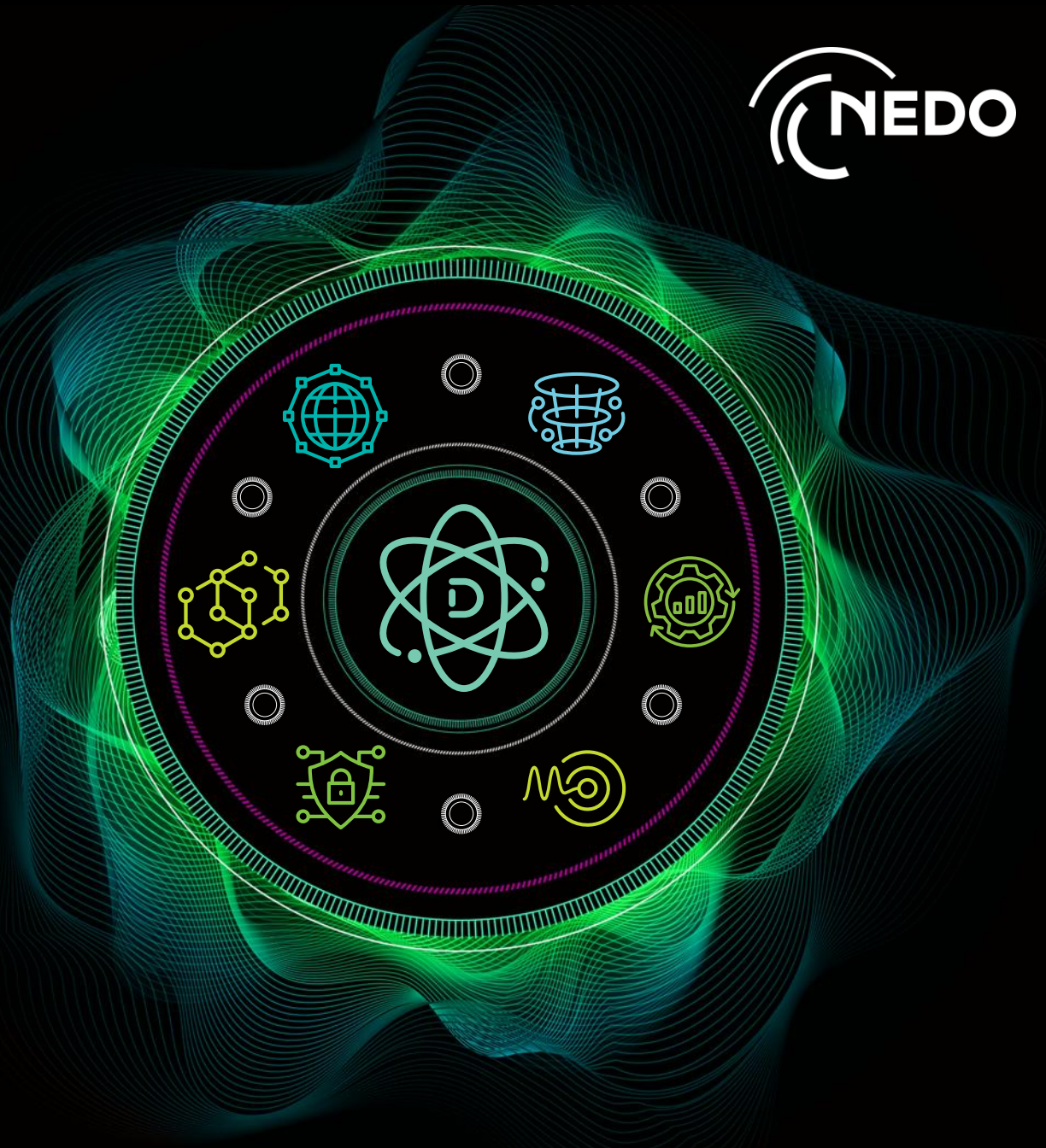
Quantum Computing Use Cases

Simultaneous Anomaly Detection for Multiple Facilities Using Non-Contact Sensors with Quantum Kernel Technology

TOPPAN and JAXA



New Energy and Industrial Technology Development Organization (NEDO)

TOPPAN and JAXA: Simultaneous Anomaly Detection of Multiple Facilities Using Non-Contact Sensors based on Quantum Kernel Technology [2026/7] 1/2

Validation

Industry	Discrete Manufacturing
Process	Production
Method	AI
Category	Gate*

Background

■ **Social issues and the loss of skilled know-how:**

In the manufacturing industry, the decline in the number of younger workers due to a declining birthrate and aging population, together with the retirement of experienced workers, has raised concerns about the loss of skilled craftsmanship developed through years of experience. This could ultimately weaken overall manufacturing capabilities.

■ **Current status and Challenge:**

In factory equipment monitoring, machine learning-based anomaly detection has become increasingly common. The prevailing approach is to install multiple contact-type vibration sensors on a single piece of equipment. However, as the number of monitored machines increases, the total number of sensors may reach several dozen. Consequently, operator monitoring workloads, sensor costs, and wiring complexity have become significant challenges.

■ **Limitations of Conventional Methods:**

For low-volume, high-mix production environments, the amount of available training data is often limited, making it difficult to construct highly accurate machine learning models. As a result, in actual manufacturing facilities, skilled operators frequently patrol the factory and use their own hearing to identify abnormal sounds (time-series data) and assess the operational conditions of multiple machines simultaneously.

Motivation

■ **Specific issue to be solved:**

Replace the use of many contact-type vibration sensors with acoustic information from non-contact sensors such as microphones. In an environment where multiple machines are operating and sounds interfere with each other, detect and identify multiple anomalies simultaneously using only a small number of sensors

■ **KPI improvement:**

- Anomaly detection performance equivalent to or better than contact-type sensors (F2 score ≥ 0.9).
- Reduce sensor installation costs.
- Eliminate wiring requirements.

■ **Why quantum computing technology was considered effective:**

Quantum computers can map data into high-dimensional quantum feature spaces. Compared with classical vector spaces, they can represent and process a larger number of features simultaneously, offering superior expressive power. This characteristic makes them particularly suitable for analyzing complex combinations of factors

Reference: Ministry of Economy, Trade and Industry (METI), 2024 White Paper on Manufacturing (https://www.meti.go.jp/report/whitepaper/mono/2024/index.html)

*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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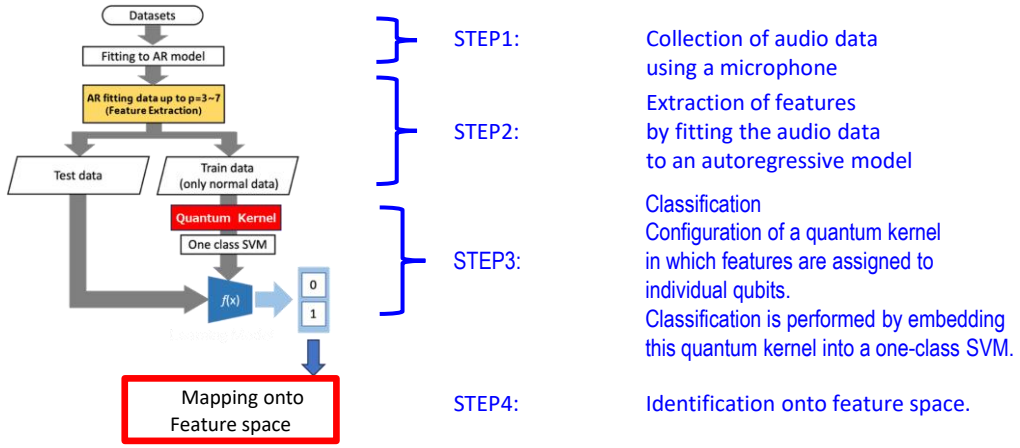
Problem formulation for quantum computer

■ **Input data and method**:

Audio data (time-series data) collected by microphones is fitted to an autoregressive (AR) model to extract coefficients as features. These features are mapped into a quantum feature space and embedded into a one-class SVM for learning and classification of normal and abnormal states

■ **Why classical methods are difficult**:

In complex acoustic environments where multiple machines operate simultaneously, **classical kernels such as the RBF kernel produced performance metrics of 0.5 or lower, making discrimination nearly impossible**. Accuracy also dropped rapidly as the distance from the microphone increased. In contrast, the quantum kernel achieved performance metric close to 1.0, confirming stable and highly accurate detection even from a distance of 3 meters



Pipeline

Audio data are converted into feature vectors and then classified and identified using a quantum-kernel OC-SVM

Expected business impact

■ **Operational and business benefit:**

If a single non-contact sensor can detect anomalies in multiple pieces of equipment, **initial sensor installation costs as well as wiring and maintenance costs can be significantly reduced. In addition, a visual diagnostic function that intuitively identifies failure locations can reduce the burden on maintenance staff**

■ **Impact through solution integration:**

By incorporating this technology into TOPPAN's cloud platform for integrated manufacturing DX solutions (NAVINECT and DockGator), rapid corrective actions such as automatic control based on signs of anomalies can be achieved

■ **Quantitative outlook:**

This technology is expected to contribute to a new market of JPY 3.85 billion per year by 2035 and to reduce CO2 emissions by 44,000 tons per year

$$562\ \text{Mt} \times 7.8\% \times 0.1\% = 0.044\ \text{Mt/year}$$

Reference of technical background:
Tomono, T., Tsujimura, K. Potential of multi-anomalies detection using quantum machine learning. Quantum Mach. Intell. 8, 106 (2026). https://doi.org/10.1007/s42484-026-00448-8
Tomono, T., Tsujimura, K. Hybrid quantum-classical machine learning for industrial multi-anomaly detection via single acoustic sensor. Sci Rep (2026). https://doi.org/10.1038/s41598-026-61786-y
T. Tomono and K. Tsujimura, "Quantum Kernel Anomaly Detection Using AR-Derived Features from Non-Contact Acoustic Monitoring for Smart Manufacturing," 2025 IEEE International Conference on Quantum Computing and Engineering (QCE), Albuquerque, NM, USA, 2025, pp. 1776-178. https://doi.org/10.1109/QCE65121.2025.00195

Reference of CO2 reduction:
excerpted from Ministry of the Environment and METI, "Aggregated Results of Greenhouse Gas Emissions for FY2020 under the Calculation, Reporting, and Disclosure System Based on the Act on Promotion of Global Warming Countermeasures" (https://policies.env.go.jp/earth/ghg-santeikohyo/files/result/r02/result_R2_20231027.pdf)

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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”.