Quantum Computing Use Cases

Faster readout of quantum computing results

Quemix × Sumitomo Rubber Industries



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

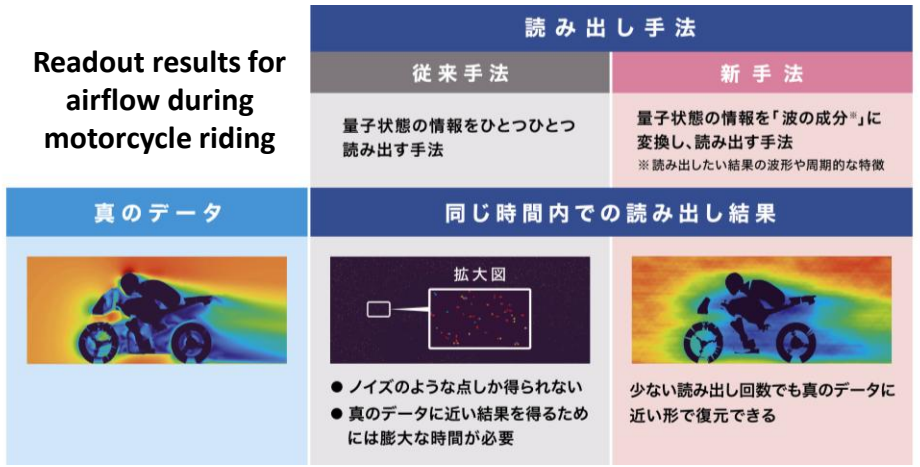
Industry	Others
Process	Others
Method	Others
Category	Gate*

Background

- Sumitomo Rubber has positioned **“creation of innovation originating from rubber” as one of the growth drivers in its long-term management strategy, R.I.S.E. 2035, and aims to accelerate the development of high-performance rubber materials**
- In recent years, quantum computers have been expected to be applied in fields such as materials development, fluid analysis, and finance. However, **practical use faces a technical challenge known as the readout problem. While quantum computation itself can be performed at high speed, extracting the results accurately as numerical values requires enormous cost, which can negate the advantage of quantum computation**. For this reason, there has been skepticism about whether the advantages of quantum computation can be utilized in the CAE field
- A particularly significant issue is the solution of nonlinear equations, which is a central challenge in CAE analysis for reproducing complex physical phenomena such as structural deformation, fluid vortices, and heat transfer. Although **conventional quantum algorithms have theoretically shown the possibility of acceleration, the time and cost required to read out the results have prevented their practical benefits from being realized**

Issues and motivation to be solved

- **Significantly reduce the time and cost required for the readout process of quantum computation results in solving nonlinear equations**
  - Overcome the readout problem so that the theoretical speed of quantum computers can be realized in actual computation
  - Improve the industrial competitiveness of quantum computation in areas requiring massive computational resources, such as material property analysis and fluid simulation
- Through the above, **greatly accelerate the development speed of new materials such as high-performance rubber**



Reference: Exponential acceleration of nonlinear equation computation using a quantum computer — Sumitomo Rubber and Quemix develop a new method for faster readout of results（https://www.srigroup.co.jp/newsrelease/2025/sri/2025_089.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.

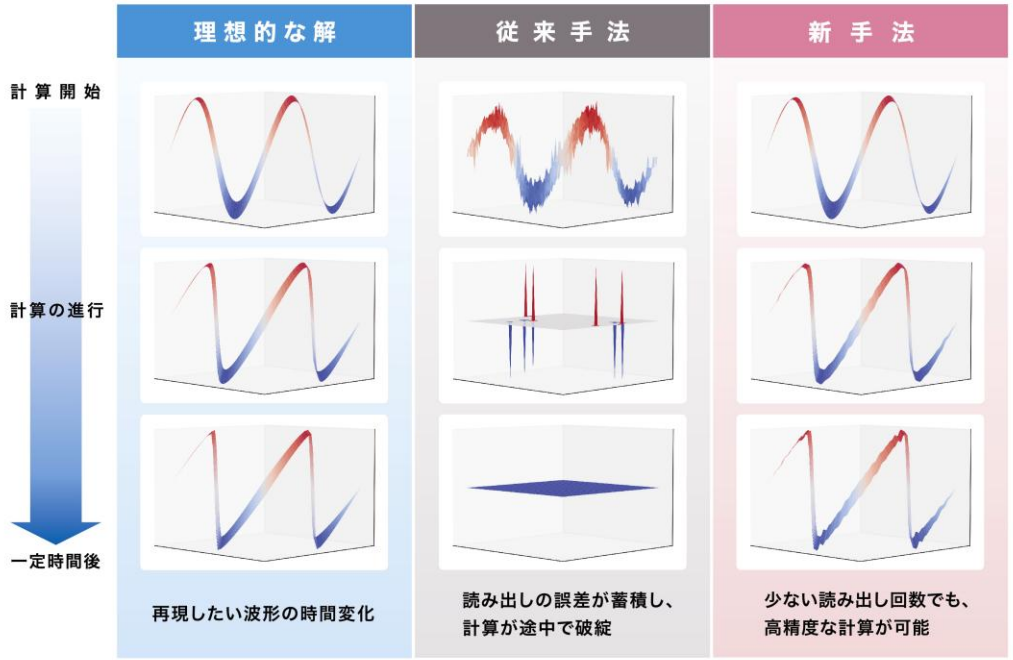
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Validation

Industry	Others
Process	Others
Method	Others
Category	Gate*

Problem setting as a quantum computer

- **The target is the solution of nonlinear equations, where the relationship between input and output is not simple proportionality but involves complex interactions**
  - These equations represent many real-world physical phenomena, such as structural deformation, fluid vortices, and heat transfer, and are a highly computationally intensive area in CAE analysis
  - In this joint research, a method was developed to efficiently extract waveform and periodic features contained in quantum-computed functions, such as Fourier coefficients, and reconstruct the solution from a small number of principal components
- This method enables **a readout protocol that maintains processing efficiency even as data volume increases and can support large-scale simulations**



Left figure: Comparison of calculation results between the conventional method and the new method for nonlinear equations

(Calculation results for the Burgers equation used in this demonstration The figure shows the progression of calculation steps from top to bottom)

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Validation

Industry	Others
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Method	Simulation
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Expected business benefits

- **With the introduction of this readout protocol, quantum computation results for nonlinear equations, which previously required repeated state measurements, can now be obtained rapidly and at lower cost, enabling the theoretical speed of quantum computing to be realized in actual computation**
  - ✓ Demonstrations using the Burgers equation and polymer SCFT (Self-Consistent Field Theory) calculations confirmed exponential improvement in computational speed
- **As a result of this work, Sumitomo Rubber has gained the possibility of significantly shortening analysis processes in the development of high-performance rubber materials that previously took from several weeks to several months using conventional computational methods**
  - ✓ By making it possible to realize the theoretical speed of quantum computers in actual nonlinear equation calculations, it may become possible to build a competitive computational foundation in fields such as material property analysis, fluid simulation, and financial risk assessment
- **This is expected not only to accelerate R&D, but also to reduce development costs and shorten time to commercialization**. In addition, the results suggest a new R&D direction in quantum algorithm design, in which both the computational method and the readout protocol are optimized in an integrated manner, and are expected to accelerate industrial applications of quantum computing in the CAE field

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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".