Designing Better Quantum Neural Networks with Continual Learning

Morgan State University’s Research on Online Neural Architecture Search for Quantum AI

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Abstract

Quantum computing has the potential to transform how we use artificial intelligence. But it faces one major problem: quantum noise. This noise comes from the environment and makes quantum computers unstable. As student researches at Morgan State University, we are using artificial intelligence to help solve this problem. Our research focuses on using continual learning to improve quantum neural networks. We do this by searching for the best network designs over time, even as the system changes. This paper shows how our team combines quantum computing, neural architecture search, and machine learning. The goal is to make quantum AI more reliable and smarter as it learns.

1. Introduction

Quantum computers use qubits, which are different from regular computer bits. Qubits can be in more than one state at once. This makes them very powerful. But qubits are also very sensitive. They are easily disturbed by noise. This noise causes errors in quantum calculations. These errors are a big problem for quantum artificial intelligence.

In this study, we look at how AI can help. We use something called continual learning. This means the AI system keeps learning and adjusting as it gets more information. We also use neural architecture search. This helps the AI find better designs for quantum neural networks, even while the system is running.

2. The Problem with Quantum Noise

Quantum noise comes from many sources:

Heat can cause qubits to lose their special state.

Magnetic and electric signals can interrupt qubit operations.

Small flaws in the quantum chip can create errors.

Tiny mistakes in controlling the quantum computer can make things worse.

Because of this, quantum systems often make mistakes. These mistakes are a big challenge, especially when we want to use them for learning tasks like AI.

3. Our Research Focus

Our goal is to use machine learning to make quantum systems more stable and reliable. We do this by letting the AI system:

Keep learning as the environment changes

Adjust the structure of quantum neural networks automatically

Respond to noise in real time

4. Continual Learning and Neural Architecture Search

4.1 What is Continual Learning?

Continual learning means the AI system keeps updating its knowledge as new data comes in. It does not need to start from scratch every time. This helps the AI system stay useful even when the quantum system is noisy or unstable.

4.2 What is Neural Architecture Search?

Neural architecture search is a way to let AI design its own network. It tries many different shapes and connections. It picks the ones that work best. In our case, the AI tries different quantum neural network structures. It finds the one that works best with the current noise conditions.

4.3 Why Combine the Two?

Continual learning helps the AI system adapt over time. Neural architecture search helps it find good designs. Together, they allow our system to stay accurate and stable even when conditions change.

5. Our Approach

5.1 Data Collection

To achieve this, we plan to use real quantum computers like IBM Q and Rigetti, or we use simulators built using platforms like IBM Qiskit. Our aim is to collect data such as:

Qubit states

Error rates

Temperature and electrical noise

Performance of different quantum circuits

5.2 Model Training

Then, we train the AI to:

Spot noise patterns

Predict which designs will fail

Recommend better designs for the quantum neural networks

5.3 Deployment

The AI system is deployed alongside the quantum computer. It monitors, learns, and adapts in real time. It can change the network design or suggest better calibration settings to reduce errors.

6. Results So Far

Our system would be tested on real quantum hardware. Some of the results we hope to achieve:

Fewer percent fewer errors in quantum circuits

Quantum AI models which are more stable and train faster

Quantum neural networks which are better at solving test problems

These results would be a good step toward more reliable quantum computing for AI tasks.

7. Training Future Scientists

Morgan State focuses on education and research. As student researchers, we hope to gain more hands-on experience with quantum computing and AI. Helpful program should include:

Courses in quantum and machine learning

Internships with research labs

Workshops with experts in the field

It is important to prepare a new generation of researchers who can work on future quantum systems.

8. What’s Next?

In the future, we plan to:

Use this approach with more complex quantum systems

Mix classical and quantum learning methods

Work with hardware teams to make quantum computers that respond better to AI controls

9. Conclusion

Quantum computers are powerful, but noisy. Our team at Morgan State University hopes to make them smarter and more stable. By using continual learning and neural architecture search, we can help quantum AI systems learn and grow over time. This makes quantum computing more useful for real-world applications.