Milestone 1 Progress Report:
Quantum Clustering Educational Module

May 30, 2025

Contents

1 Overview

Milestone 1 established the foundation for the quantum clustering educational module. We built a comprehensive learning experience that covers both classical and quantum approaches to clustering algorithms.

2 Key Components Implemented

2.1 Introduction to Clustering and Quantum Clustering

Created a complete introduction section that explains:

- What clustering is and why it matters
- Basic concepts of unsupervised machine learning
- Introduction to quantum computing applications in clustering
- Overview of quantum advantages in machine learning

2.2 Classical K-Means Clustering

Built a comprehensive section covering classical approaches:

- Literature review of traditional k-means algorithms
- Code demonstration with implementation on synthetic data
- MCQ quiz to test student understanding of classical concepts

2.3 Quantum Encoding Strategies

Developed detailed content on quantum data encoding:

- Literature review of quantum encoding methods
- Code demonstrations with visual representations
- Circuit diagrams showing quantum encoding processes
- Bloch sphere visualizations to show quantum states
- MCQ quiz covering quantum encoding concepts

2.4 Quantum K-Means Implementation

Created the core quantum clustering content:

- Literature review of quantum k-means algorithms
- Code demonstration implementing quantum k-means on synthetic data
- Used state fidelity as the distance metric for quantum similarity

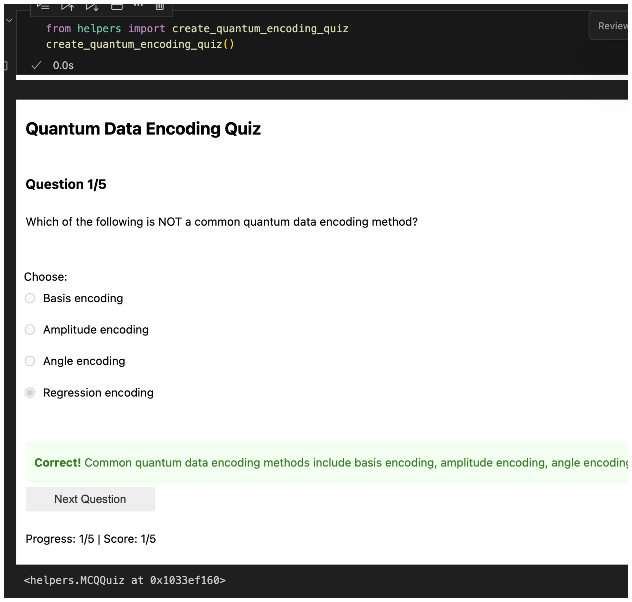

Figure 1: MCQ quiz in jupyter notebook

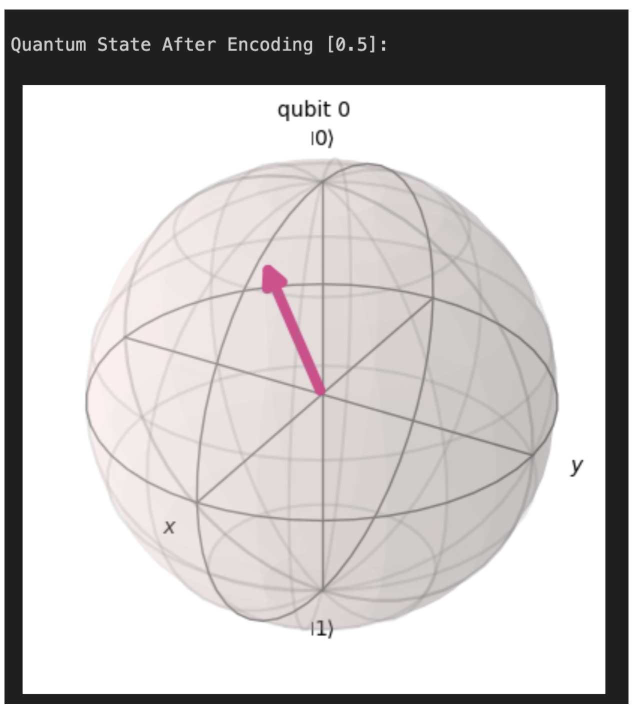

Figure 2: Bloch sphere visualization in jupyter notebook

- Analysis section explaining quantum advantages and limitations
- Swap test implementation for quantum distance computation
- Code demo showing swap test on synthetic data
- MCQ quiz testing quantum k-means understanding

2.5 Practical Challenges Section

Added real-world considerations:

- Discussion of current quantum hardware limitations
- Noise and error considerations in quantum implementations
- Scalability challenges for quantum clustering
- Comparison between classical and quantum performance

2.6 Coding Exercises

Suggested activities for students to explore quantum clustering further:

- Implement a quantum clustering algorithm for a dataset of your choice
- Compare the results with classical clustering
- Visualize the clusters and analyze the performance

2.7 Educational Structure

Organized content for effective learning:

- Clear progression from classical to quantum concepts
- Multiple assessment points throughout the module
- Interactive coding components
- Visual aids and demonstrations

3 Conclusion

In milestone 1, we developed an educational module that introduces quantum clustering concepts, from basic principles to more advanced implementations. The module combines theoretical content with hands-on coding exercises. Students explore classical k-means, learn about quantum encoding methods, try implementing quantum k-means algorithms, and experiment with quantum distance metrics such as state fidelity and swap tests. Through a mix of readings, code examples, visual materials, and quizzes, the module aims to provide a practical introduction to quantum machine learning concepts.