

Quantum Machine Learning

Theory, Algorithms, and Practical Implementation

Quantum machine learning has emerged as a rapidly developing field at the intersection of quantum computing, artificial intelligence, and data science. As quantum hardware and algorithms continue to advance, there is a growing need for a rigorous and accessible text that explains how quantum principles can be used to design, analyze, and implement machine learning models. This book is intended for graduate students, researchers, and practitioners in computer science, physics, engineering, mathematics, and related disciplines. The book provides a comprehensive introduction to the foundations and modern methods of quantum machine learning. It begins with the principles of quantum information, Hilbert spaces, quantum circuits, and quantum algorithms relevant to learning tasks, and then develops the major paradigms of the field, including quantum data encoding, quantum feature maps and kernels, variational quantum circuits, quantum neural networks, quantum generative models, quantum reinforcement learning, quantum transfer learning, and quantum linear algebra techniques. The text emphasizes both theory and implementation, with programming examples and computational workflows using Qiskit, PennyLane, TensorFlow Quantum, and PyTorch. Additional chapters address tensor-network-inspired learning, error mitigation, GPU-accelerated simulation, benchmarking, hybrid quantum-classical architectures, and applications in chemistry, genomics, finance, optimization, and natural language processing. Distinctive in both scope and organization, the book integrates mathematical foundations, algorithmic development, software implementation, and emerging research directions within a single coherent framework, making it suitable both as a graduate-level textbook and as a practical reference for researchers working in quantum machine learning.

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