

Equivariant Quantum Neural Networks: Leveraging Data Symmetry for Enhanced Learning

Lazaro R. Diaz Lievano.

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Abstract

In the realm of quantum machine learning, Equivariant Quantum Neural Networks (EQNNs) represent a significant advancement by incorporating symmetry transformations into the model architecture. Our work focuses on designing quantum neural networks whose outputs remain invariant under specific symmetry transformations of the input data, encompassing both discrete symmetries like reflections and continuous symmetries such as rotations. By embedding these symmetries into the network structure, we aim to reduce the number of trainable parameters, mitigate barren plateaus, and enhance generalization capabilities even with limited data.

Building on foundational principles from representation theory, we construct equivariant gatesets that ensure the symmetry properties of the problem are preserved throughout the learning process. Our results demonstrate that EQNNs outperform their conventional quantum and classical counterparts in various cases, providing a robust framework for different learning tasks. This symmetry-aware approach not only streamlines the learning process but also aligns with the natural structure of the data, facilitating more efficient and effective training. The implications of our findings extend to a broad spectrum of quantum machine learning applications, suggesting that EQNNs hold promise for tackling complex problems with inherent symmetrical structures.