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Learning to generate high-dimensional distributions with low-dimensional quantum Boltzmann machines

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In recent years, researchers have been exploring ways to generalize Boltzmann machines (BMs) to quantum systems, leading to the development of variations such as fully-visible and restricted quantum Boltzmann machines (QBMs). Due to the non-commuting nature of their Hamiltonians, restricted QBMs face trainability issues, whereas fully-visible QBMs have emerged as a more tractable option, as recent results demonstrate their sample-efficient trainability. These results position fully-visible QBMs as a favorable choice, offering potential improvements over fully-visible BMs without suffering from the trainability issues associated with restricted QBMs. In this work, we show that low-dimensional, fully-visible QBMs can learn to generate distributions typically associated with higher-dimensional systems. We validate our findings through numerical experiments on both artificial datasets and real-world examples from the high energy physics problem of jet event generation. We find that non-commuting terms and Hamiltonian connectivity improve the learning capabilities of QBMs, providing flexible resources suitable for various hardware architectures. Furthermore, we provide strategies and future directions to maximize the learning capacity of fully-visible QBMs.

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Short summary

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