Structure-Optimized Tensor Network Generative Models for Data Distributions

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Tensor networks are well established as efficient representations of quantum many-body states and have recently emerged as promising generative models for classical data distributions. In this workshop, I will introduce a novel approach to tensor network–based generative modeling, where both the tensor parameters and the *network structure* are jointly optimized using data [1,2].

By adapting the connectivity and geometry of the tensor network to match the underlying data distribution, this method achieves high expressive power while maintaining strong parameter efficiency. Our results show that a wide variety of data distributions can be represented with significantly fewer trainable parameters than conventional generative models. The performance of this approach is benchmarked against restricted Boltzmann machines and autoregressive models, demonstrating its advantages.

Additionally, I demonstrate that gradually increasing the minibatch size during training offers an effective strategy for stable optimization of the network structure. Together, these findings showcase a novel application of tensor network techniques—originally developed in quantum and statistical physics—to data-driven generative modeling. This work highlights tensor networks as a physically motivated, efficient alternative to standard machine learning architectures.

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[1] Kenji Harada, Tsuyoshi Okubo, and Naoki Kawashima, *Tensor tree learns hidden relational structures in data to construct generative models*, Machine Learning: Science and Technology ***6*** 025002(2025).
[2] Katsuya O. Akamatsu, Kenji Harada, Tsuyoshi Okubo, and Naoki Kawashima, *Plastic tensor networks for interpretable generative modeling,* arXiv:2504.06722.