Quantum Tensor Networks, Stochastic Processes, and Weighted Automata

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24th International Conference on Artificial Intelligence and Statistics, 2021

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All Models Considered

Quantum Tensor Networks

- uBM = Uniform Born Machine
- uLPS = Uniform Locally Purified State
- uMPS = Uniform Matrix Product State

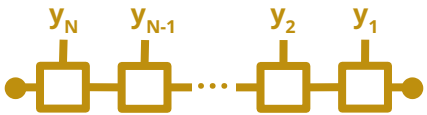
Weighted Automata

- PA = Probabilistic Automata
- QWA = Quadratic Weighted Automata
- SWA = Stochastic Weighted Automata

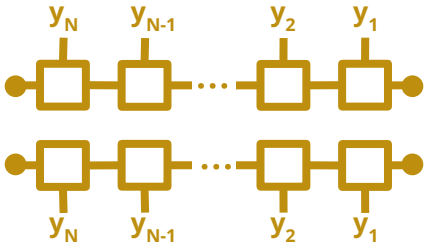
Stochastic Processes

- HMM = Hidden Markov Model
- NOOM = Norm Observable Operator Model
- HQMM = Hidden Quantum Markov Model
- PSR = Predictive State Representation

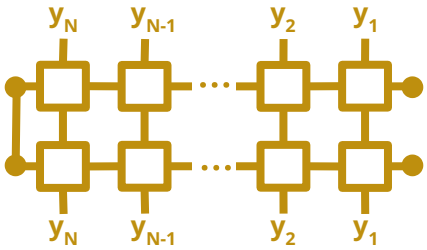
Uniform Tensor Networks for Probabilistic Modeling



uMPS = Uncontrolled PSR = SWA



uBM

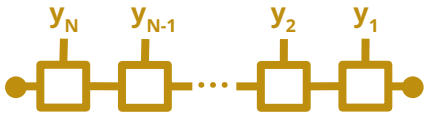


uLPS

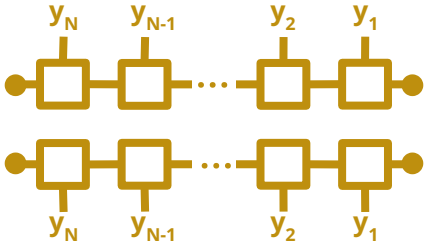
- Glasser et al. (2019) establish relative expressiveness relationships between various *non-uniform* quantum tensor networks (QTNs).
- Uniform tensor networks can compactly represent structured data, and we explore various relationships
- We show formal equivalence of various uniform QTNs to stochastic process models like HMMs/PSRs/HQMMs and automata models like PA/SWA/QWA.
- We also study their relative expressiveness relationships.

Glasser, I., Sweke, R., Pancotti, N., Eisert, J., & Cirac, J.I. (2019). Expressive power of tensor-network factorizations for probabilistic modeling, with applications from hidden Markov models to quantum machine learning. *NeurIPS*.

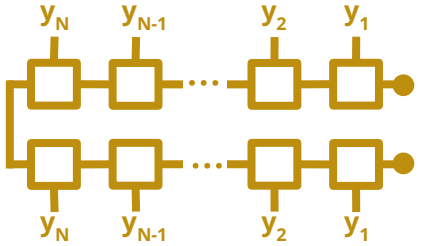
Model Equivalence



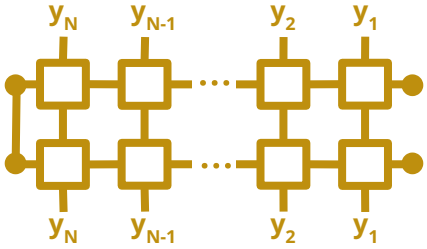
uMPS = Uncontrolled PSR = SWA



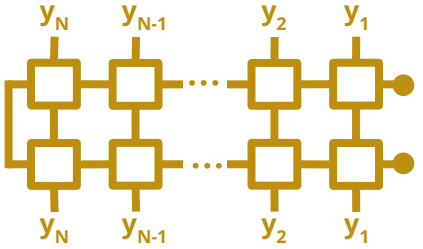
uBM



NOOM = QWA

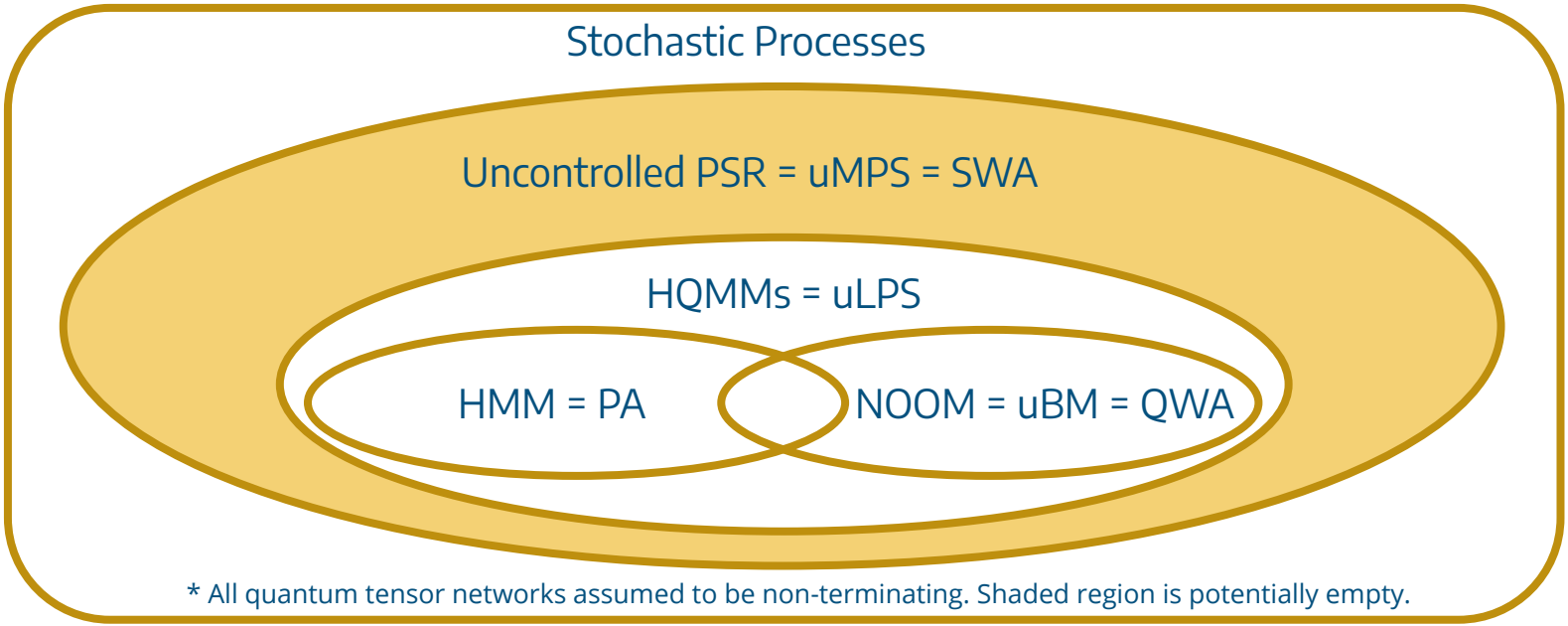


uLPS



HQMM

Expressiveness Relationships



Summary of Results

- HQMM = uLPS
- NOOM ⊂ HQMM
- HMM ⊄ NOOM
- NOOM = uBM
- uBM ⊄ HMM

Thank you