

Rough landscape of machine learning application to quantum many body problems

Collective wisdom of Anna Keselman, Ehsan Khatami, Eun-Ah Kim, Michael Lawler
Yoni Schattner, present week of Jul 24, 2017 at KITP

A rapidly growing subject! 207 total hits on cond-mat when searching for machine learning in the abstract, 110 since 2016

A handy reference on Neural Network based ML: An open source book by Michael Nielsen <http://neuralnetworksanddeeplearning.com/>
An introduction by a CS colleague Kilian Weinberger
<http://cornell.videonote.com/videos/1000481/play?t=1654.958939>

Neural network (aka AI) based approaches

- Representing Wave function
 - Variational Wave Function represented through neural networks
<https://arxiv.org/abs/1606.02318>, Carleo & Troyer, Science (2017)
 - Mapping Tensor Network to Neural network
<https://arxiv.org/pdf/1701.04831.pdf> Tao Xiang
- Neural Network Representation of Ground State WF of solvable models
Dong-Ling Deng, Xiaopeng Li, Das Sarma
<https://arxiv.org/abs/1609.09060>
<https://arxiv.org/abs/1701.04844>, PRX (2017)
- Detecting Phases
 - Goals
 - Speed-up in PD acquisition
 - Diagnose phases without good measure (MBL phases, short-range order, Topological Phases with disorder)
 - Input source
 - 1) Quantum Monte Carlo generated input
 - 2) ED on disordered systems
 - 3) Experimental Data
 - Supervised
 - 2D Ising model & 2D Ising lattice gauge theory [arXiv:1605.01735](https://arxiv.org/abs/1605.01735)
Carrasquilla and Melko, Nature Physics (2017)
 - Finite-T repulsive U 3D Hubbard [arXiv:1609.02552](https://arxiv.org/abs/1609.02552) Melko, Khatami et al
 - Zero-T repulsive U honeycomb Hubbard [arXiv:1608.07848](https://arxiv.org/abs/1608.07848) Melko, Trebst et al
 - Fractional Chern Insulator, [arXiv:1611.01518](https://arxiv.org/abs/1611.01518), Yi Zhang & E-AK, PRL, Physics Viewpoint (2017)

- Z2 QSL with mutual statistics, [arXiv:1705.01947](#), Yi Zhang, Melko, E-AK
- MBL, [arXiv:1704.01578](#) Neupert et al
- Hard-core bosons: superfluids, KT, Semi-supervised, [arXiv:1707.00663](#), Broecker, Assaad, Trebst
- Unsupervised (PCA and Autoencoders): so far, all classical.
 - [arXiv:1606.00318](#) Lei Wang: 2D Ising
 - <https://arxiv.org/abs/1703.02435> S. Wetzel: 2D Ising, 3D XY
 - <https://arxiv.org/pdf/1704.00080.pdf> Hu, Singh, Scalatter, Various spin models including highly frustrated three component (S in $\{-1,0,1\}$) spin model).
 - <https://arxiv.org/pdf/1706.07977.pdf> Ce Wang & Hui Zhai, Classical frustrated spin model.
- Theoretical Physics of Deep Neural Networks:
 - Connection between RG and fully connected deep network, [arXiv:1410.3831](#), Mehta and Schwab

Non-neural network based (i.e., linear) approaches

- Approximating MC probability (multi-linear regression)
Zi Yang Meng, Liang Fu [arXiv:1612.03804](#), [arXiv:1611.09364](#), [arXiv:1610.03137](#)
- Using regression to approximate solutions to integro-differential equations, Andy Millis
 - DMFT self-consistency equation [arXiv:1506.08858](#)
 - Numerical analytic continuation