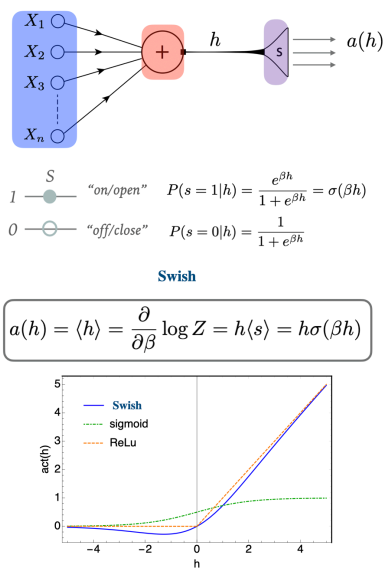
Demystifying Machine Learning Algorithms with Methods of Theoretical Physics

Thiparat Chotibut
Chula Intelligent and Complex Systems,
Department of Physics, Faculty of Science,
Chulalongkorn University
Email: thiparat.c@chula.ac.th

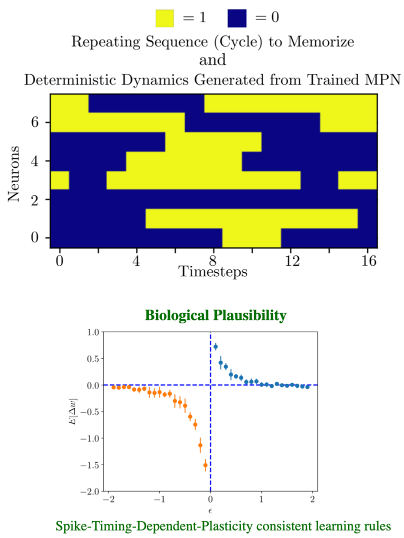
Abstract

Modern economies are fuelled by Machine Learning (ML) algorithms. Despite their ubiquitous empirical successes, many useful algorithms exhibit obscure numerical phenomena that call for the development of theoretical understanding. In this talk, I will first survey our recent work that apply methods of Theoretical Physics to demystify complex ML algorithms. Examples include the Maximum Entropy principle for the Swish activation function in Deep Learning [1], the non-equilibrium generalization of Hopfield neural networks for robustly reconstructing spatiotemporal memories in spiking neural networks [2], the chaotic yet ergodic dynamics arising from online (reinforcement) learning in game theory [3-5]. Lastly, I will discuss our recent effort to exploit well-developed tools in many-body quantum physics, i.e. entanglement entropy of tensor network states, to analyse information propagation and tackle explainability issues in recurrent neural networks for Natural Language Processing tasks such as sentiment analysis.

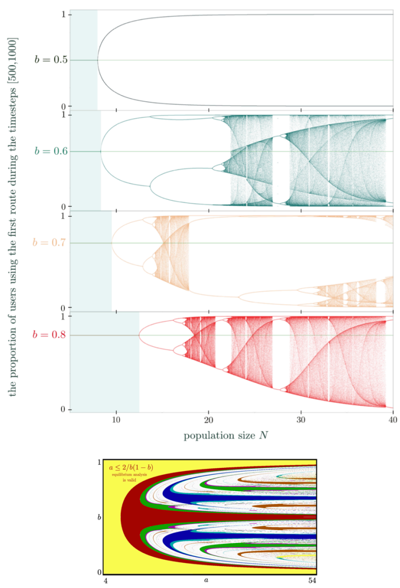
Ref. [1]



Ref. [2]



Ref. [3-5]



References

[1] Milletari, M., **Chotibut, T**., and Trevisanutto, P. E. *Mean field theory of activation functions in deep neural networks*, ICML 2019: Theoretical Physics of Deep Learning Workshop. (Link to paper)

[2] Liu, Z., **Chotibut, T**., Hillar, C., and Lin, S. *Biologically plausible sequence learning for spiking neural networks*, The Thirty-Fourth AAAI Conference on Artificial Intelligence, AAAI 2020. (Link to paper)

[3] **Chotibut, T**. et al. *Family of chaotic maps from game theory*, Dynamical Systems 2020 (Link to paper)

[4] **Chotibut, T**. et al. *The route to chaos in routing games: When is Price of Anarchy too optimistic?*, 2020 Conference on Neural Information Processing Systems, NeurIPS 2020. (Link to paper)

[5] Bielawski, J., **Chotibut, T.** et al. *Robust routes to chaos for online learning in congestion games,* in submission.