Compressing neural networks by SVD in topological phase classification problem

Dmytro Oriekhov
Badr Zouggari, Guliuxin Jin, Eliska Greplova

Kavli Institute of Nanoscience, Delft University of Technology, 2628 CJ Delft, the Netherlands

d.oriekhov@tudelft.nl

Abstract
We study the efficiency of neural networks applied to classify topological phases in one-dimensional Su-Schrieffer-Heeger model [1]. We apply singular value decomposition (SVD) to the weight matrices of layers of a trained feed-forward neural network. It is shown that by selecting a small set of largest singular values, it is possible to compress the number of free parameters in weight matrices while maintaining high accuracy of the model. We compare the results with removing the weights by replacing values below threshold by zeros. The SVD approach demonstrates advantage in maintaining precision of while reducing the memory size required for the largest and several sequential layers. This agrees with a number of observations in literature about the essential info contained in the most important singular values [2,3]. We analyse how the weight vector corresponding to largest singular value transforms dataset and performs a selection of the 'important' elements in each dataset example. This approach can be applied for compressing models discussed in recent Refs.[4-6].

References

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[4] Lei Wang, PRB 94, 195105 (2016)
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[6] P. Huembeli, et.al., PRB 97, 134109 (2018)

Figures

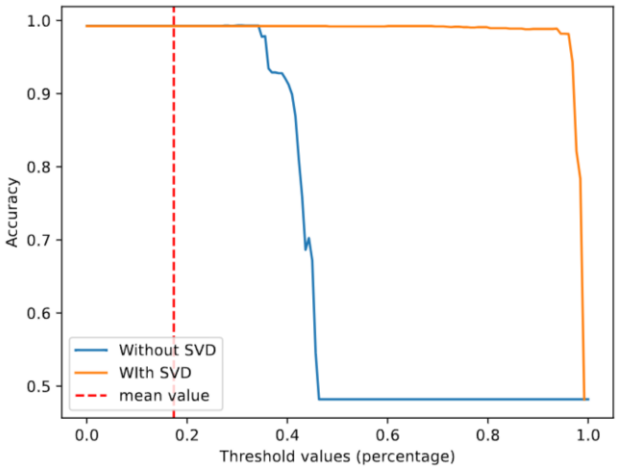

Figure 1: Performance of 3-layer feed-forward neural network with percentage of small weights weights or singular values (indicated in x-axis) being removed from the first layer. The network configuration used here is: input size 256 (all wave functions of length 16 SSH chain), output first layer 128, output second layer 64, output third layer 2. Only 8 singular values of first layer are important to maintain classification accuracy above the 95% level.

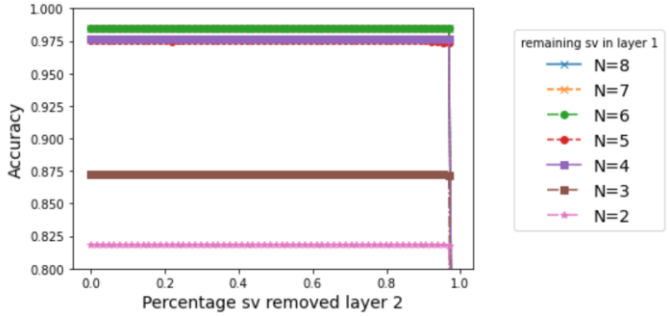

Figure 2: Accuracy of the network with few singular values left in first layer and percentage of singular values removed from second layer. Only 1 or 2 singular values in second layer store essential information for classification level of 95%. Curves correspond to number of singular values remaining in the first layer.