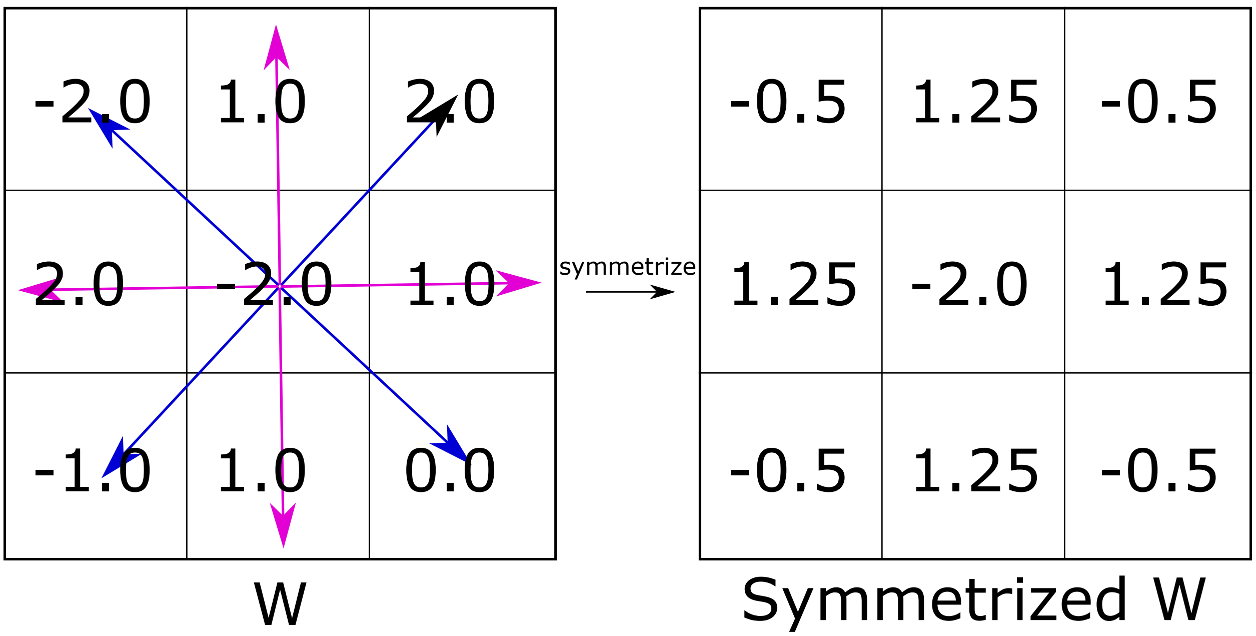
1 Introduction

2 Symmetry implementation

To perform the rotational symmetrization, the current general strategy is to choose a 3×3 convolutional kernel, place the origin at the center element, then find the groups of vectors with respect to this origin that correspond to $90°$ rotations of each other.



At the moment, we are obtaining inconsistent results. For some runs, the CRBM samples the correct states and observables, but for others it does not. We would like to then take a look at the structures of the kernels if no symmetrizations were applied to the CRBM. In the paper, it is hypothesized that the CRBM should learn the Ising model symmetries, which are: spin flip, mirror, and rotational.

3 CRBM without symmetrization

In this section, CRBM's with no symmetrization are explored for various hyperparameters. The motivation for this is two-fold: 1) See if the kernels learn Ising Model symmetries and 2)

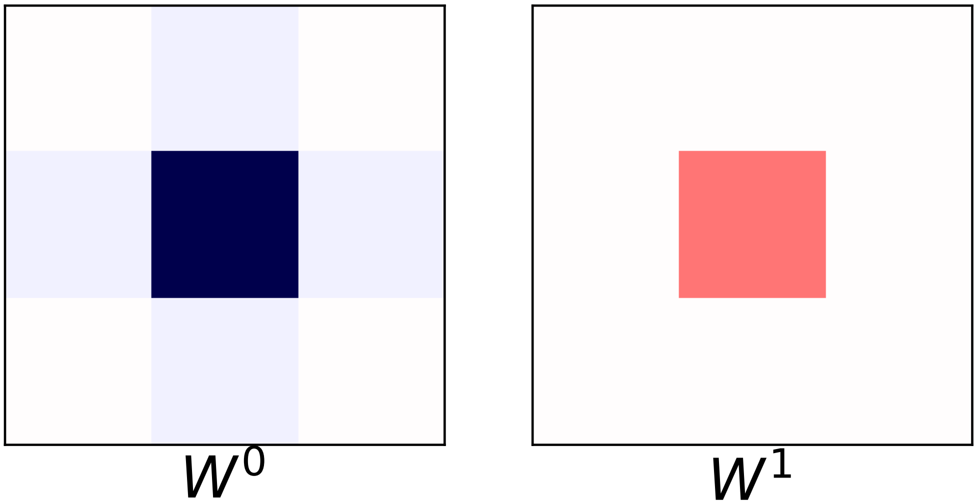


Figure 1: Example of a learned kernel at $T = 4.0$ by hard-coding rotation symmetry as prescribed.

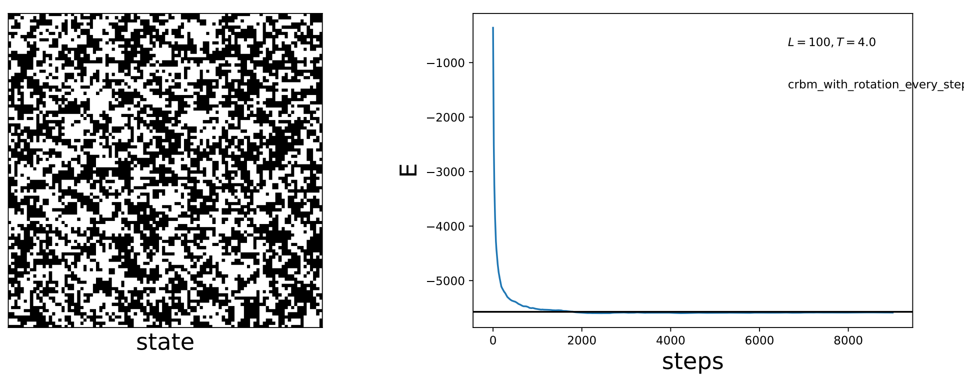


Figure 2: Example of a learned kernel at $T = 4.0$ by hard-coding rotation symmetry as prescribed.

understand what hyperparameters lead to better performance.The training for all networks has been set to stop once the loss function becomes less than 10^{-4}. Energies sampled from the CRBM will be for an Ising lattice of linear size $L = 100$, since the regime where the

CRBM beats Metropolis-Hastings is $L \geq 100$. The number of samples will be set to $100,000$.

3.1 Kernel number comparison ($T = 4.0$)

What is the effect of using different number of kernels?

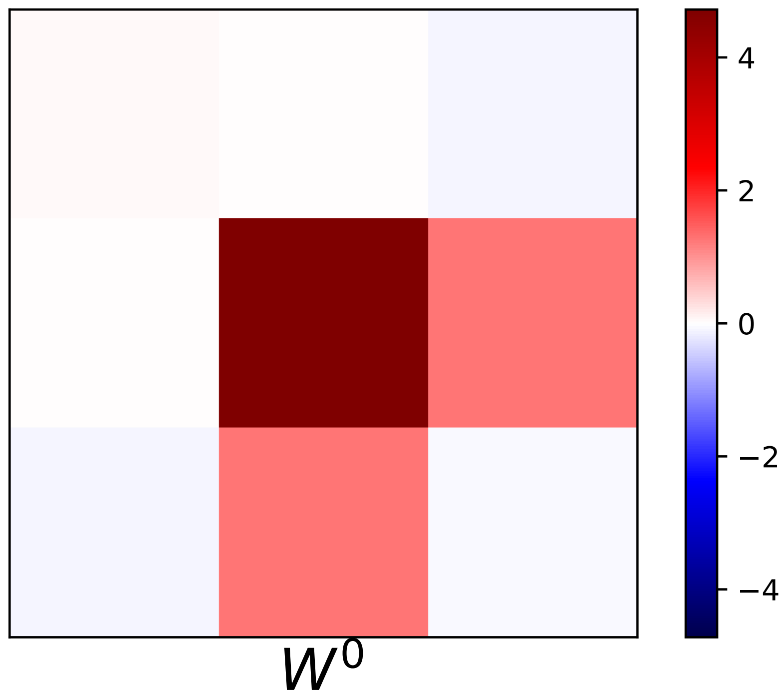


Figure 3: One 3×3 kernel

3.2 Kernel size comparison

What is the effect of varying the linear size of the kernel?

Some of the kernels almost seem to look like the symmetrized one, but shifted. What if we do an initial training round, pick the heaviest kernel element, shift it to the center, then symmetrize respect to it?

Another possible source of error is the way that the symmetrization is being implemented. Currently, it is always performed at every training step. In the thesis, they say that the

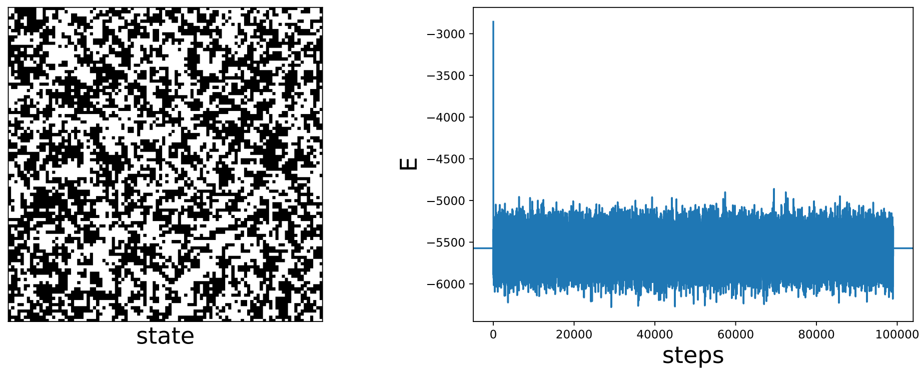


Figure 4: Final state and energy of one 3×3 kernel

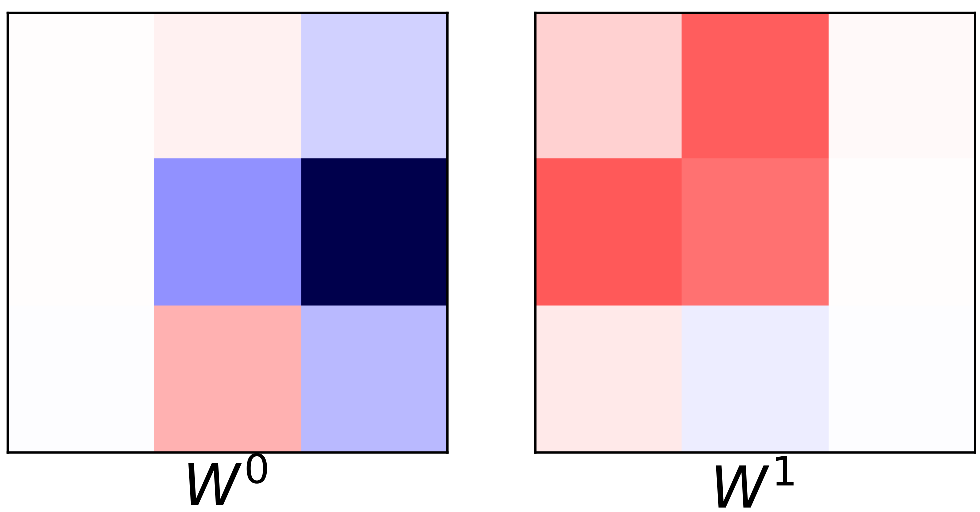


Figure 5: Two 3×3 kernels

symmetry sampling is performed by randomly picking one of the three symmetries at that step.

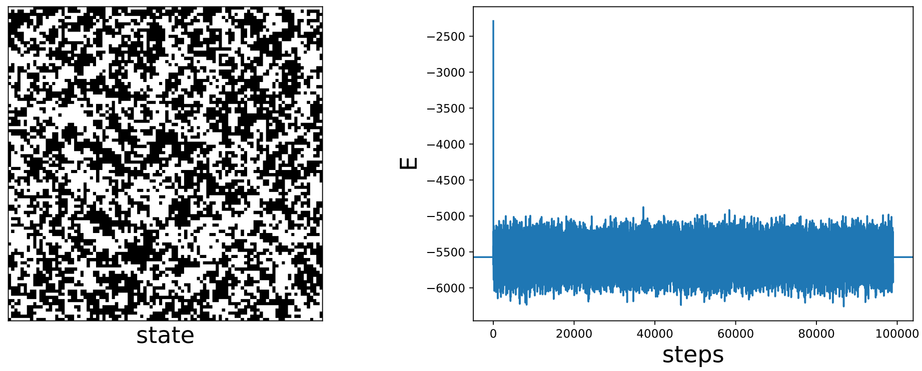


Figure 6: Final state and energy of two 3×3 kernels

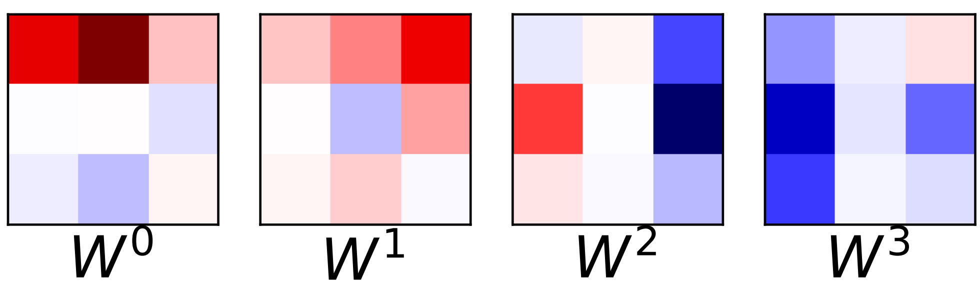


Figure 7: Four 3×3 kernels

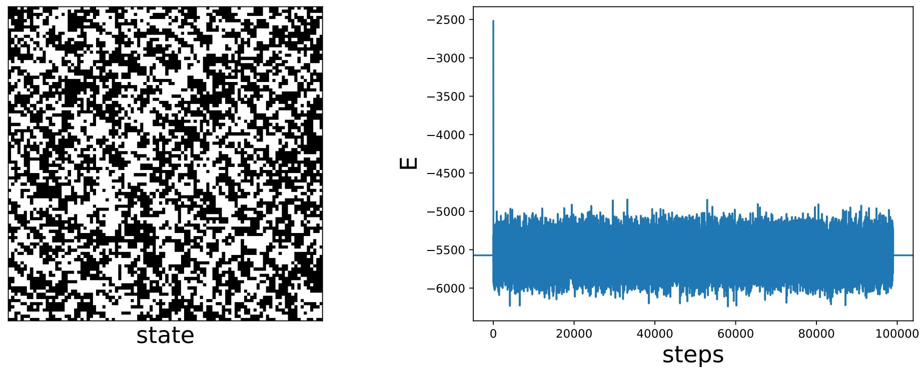


Figure 8: Final state and energy of four 3×3 kernels

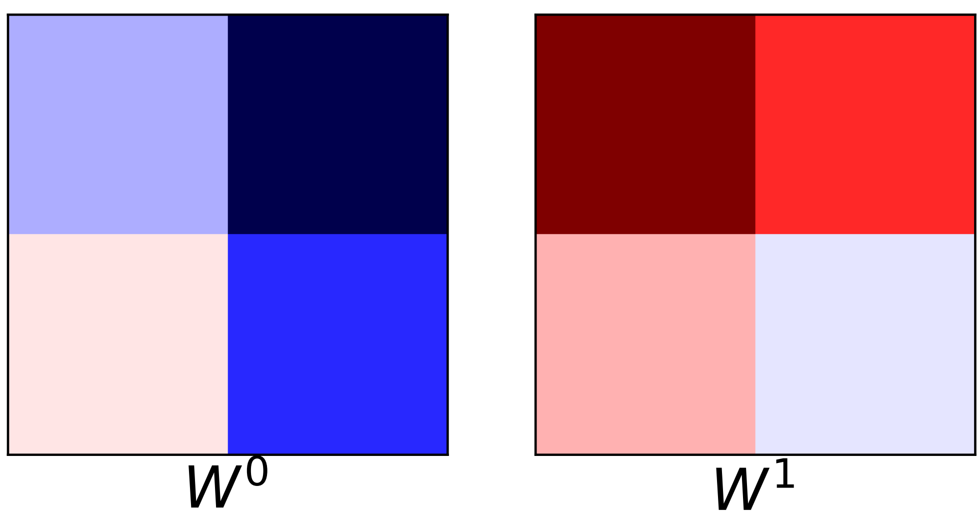


Figure 9: Two 2×2 kernels

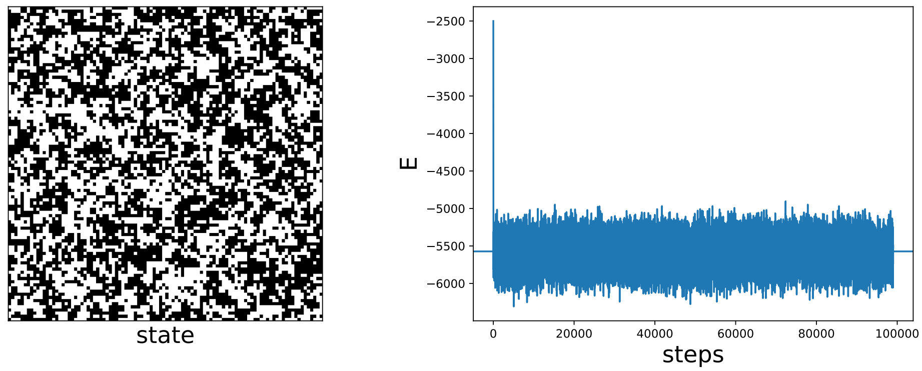


Figure 10: Final state and energy of two 2×2 kernel

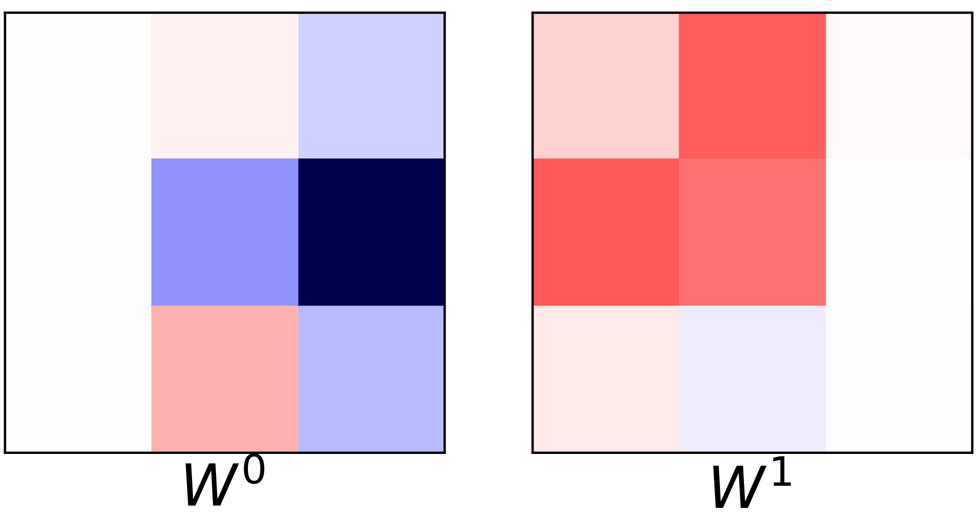


Figure 11: Two 3×3 kernels

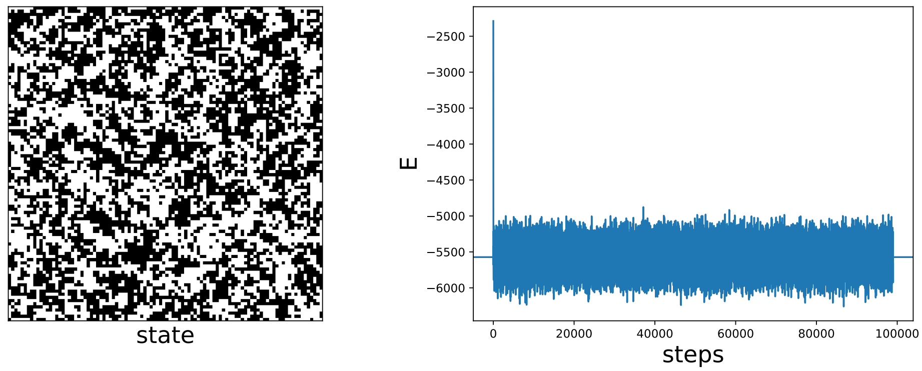


Figure 12: Final state and energy of two 3×3 kernel

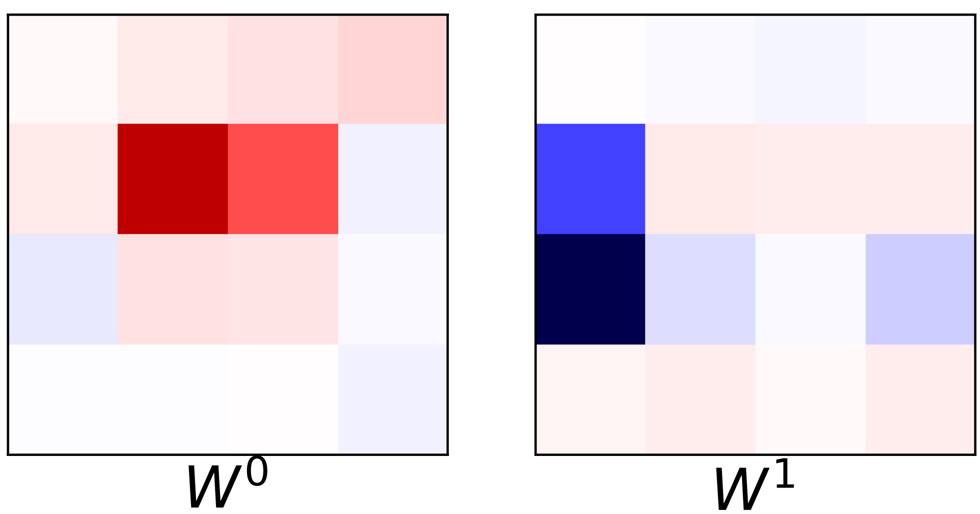


Figure 13: two 4×4 kernels

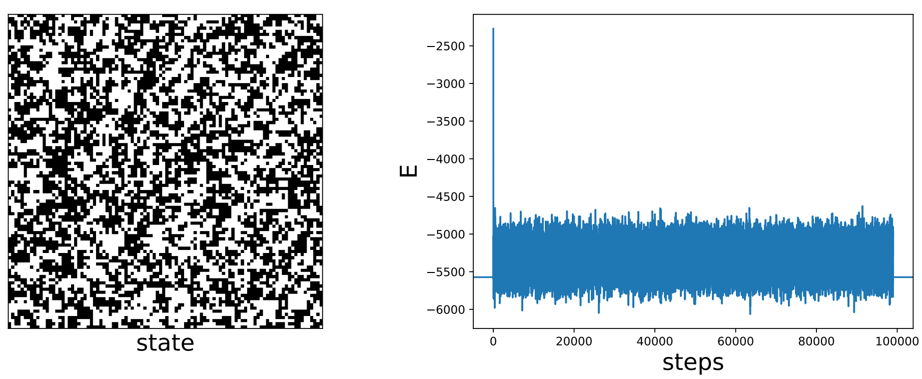


Figure 14: Final state and energy of two 4×4 kernel